Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

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November, 1956

How to Select and Specify Glass—M & M Manual No. 132

When to Use Molybdenum Alloys

Plated Coatings for Iron Powder Parts

Fabricating Steel Tubing

High Temperature Properties of Laminates

How to Use Creep Data in Design

Thermoplastic for Tough Service Conditions

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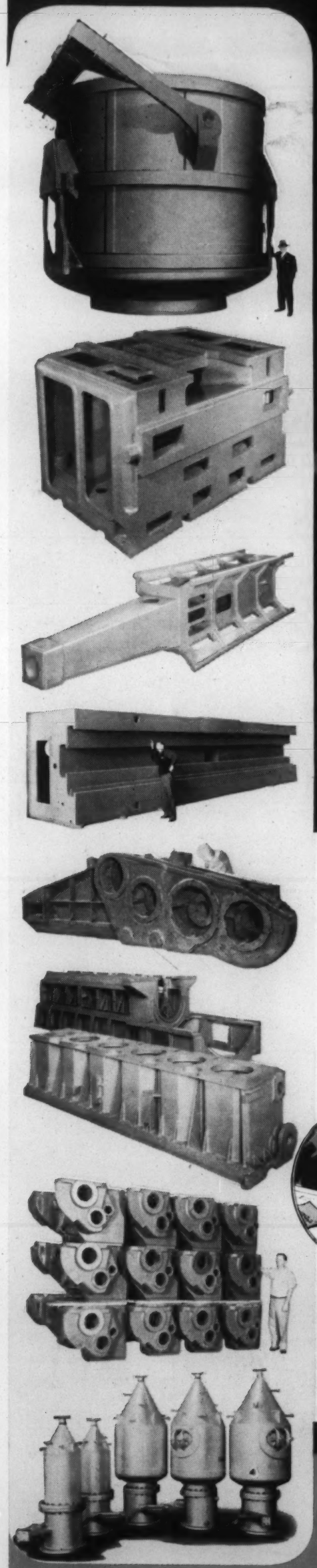

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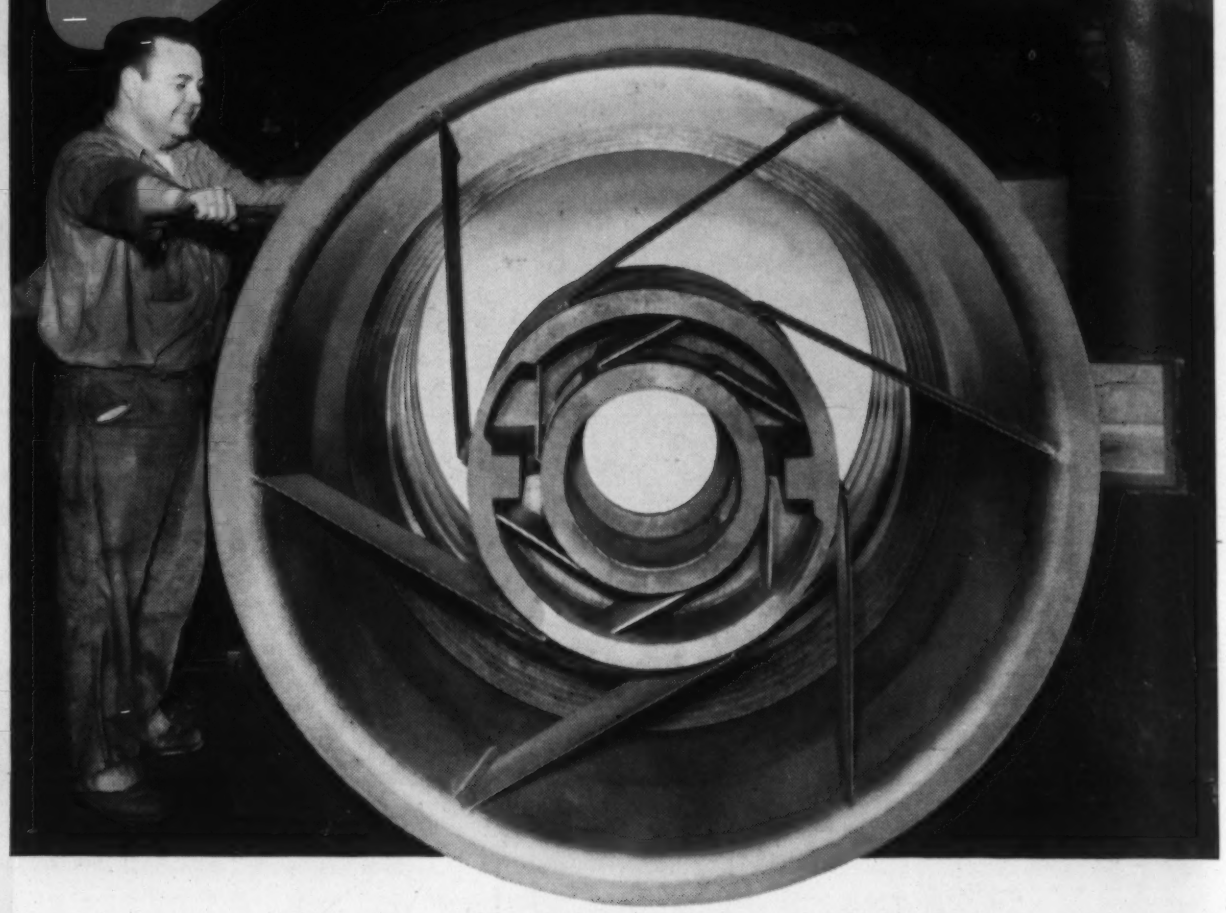

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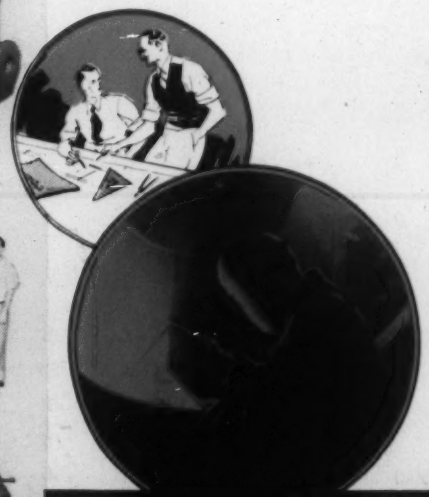

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Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

NOVEMBER 1956 **VOL. 44, NO. 5**

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In wrought Inconel "Neu-pot", KLK Manufacturing Company, Logansport, Indiana, treats small parts faster. For information about the "Neu-pot" write Rolock, Inc., Fairfield, Connecticut.

Treated in wrought Inconel pots, these small parts cost less

volume goes up, pot replacement down

These parts are done to a turn . . . in nice time, at low cost.

That's because the salt bath is contained in a Rolock "Neu-pot" made of wrought Inconel* nickel-chromium alloy.

KLK Manufacturing Company reported that unlike most "pot" materials, Inconel alloy retains original heat transfer characteristics throughout its useful service life. With it, loads can be hurried along as rapidly as good practice permits. Volume goes up, cost per piece down.

Long pot life lowers cost, too

In this installation, KLK goes on to say, Inconel nickel-chromium alloy also substantially increases pot life. They report that former pots gave, at best, only six weeks service. Their first Inconel "Neu-pot" lasted almost 5 times longer.

In overall pot expense KLK saves 50 percent by using wrought Inconel alloy. The company also realizes a major reduction in down-time. Both savings are reflected in the cost per piece.

Is high sustained heat, or heat plus severe corrosive conditions your problem? If so, look into Inconel. Write for the Inco booklet, "Keep Operating Costs Down As Temperatures Go Up."

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Materials Outlook

CONCRETE AIRCRAFT WINGS, under test in France, have aroused the interest of the Navy. Grids of prestressed piano wire reinforce prestressed concrete, and tests indicate that desirable strength can be retained with ¼-in. thickness of molded wing. With only a 3% weight penalty, the process bears investigation.

METAL FATIGUE can be studied microscopically and in slow motion with a testing machine which incorporates a clock-controlled 16-mm camera. Two microscope eyepieces allow simultaneous viewing and photographing. Information gathered should prove valuable in developing fatigue resistant materials.

A FLEXIBLE POLYESTER ELASTOMER is being molded over electrical components to form complete integral housings. It meets requirements for good dielectric properties, ability to be molded around sharp corners without cracking, and ability to be molded at low pressures. Current applications are current transformers and watt-hour meters.

RADIOACTIVE MATERIALS in strengths up to 10,000 curies can now be custom-tailored to any shape desired by a commercial facility licensed by AEC. An inventory of the more common long-life isotopes will be maintained. Staff members will supervise installation of the radioactive sources or perform tests to study the effects of radiation on materials with which the customer is concerned.

MACHINING OF METALS at any speed from 0 to 2600 fpm may be the outcome of recent experiments using two different tool materials on the same machining set-up. Reports indicate that the slow speed barrier (below 100 fpm) has been overcome with superior grades of carbides and the high speed (above 1000 fpm) with cemented oxides.

CADMIUM SULFIDE CRYSTALS have been "laboratory-grown" in sizes up to ⅝ in. in dia and several inches long. These larger crystals open the way for improvement in photo cells, solar batteries and light-producing phosphorescent materials.

CHROMIUM CARBIDE has been found to stand up extremely well in a recent high temperature corrosion application. Shafts and bearings were run in an ammonia reducing atmosphere at 2000 F for five days a week (idling two days at 1600 F) for eight months without breakdown of bearing surfaces or significant distortion of fit.

Materials Outlook

A HIGH TEMPERATURE PIEZOELECTRIC MATERIAL, lead metaniobate, is now in pilot production. Retaining most of its properties up to 930 F, it has obvious applications in missile accelerometers and safety devices to control excessive vibration.

GLASS FIBER-REINFORCED PLASTICS SHAPES of nonuniform thickness are being produced in a fully automatic process. The process involves a patented method of air-felting glass fibers and other organic fibers, such as paper pulp, into a single structure. Preforms are turned out in ½ to 2½ min, yet a constant ratio is maintained between glass reinforcement and resin regardless of thickness.

A CERAMIC THAT INDICATES HUMIDITY CHANGES rapidly (about 30 sec) even at high humidities has been developed. Its over-all change in electrical resistance is 2500 times the humidity change from 30 and 100% humidity. Response in the 90-100% range is two-fold. Conventional sensing devices are practically insensitive at 100%.

COLUMBIUM AND TANTALUM metals and oxides are available in purities up to 99.5% in volume quantities. Columbium offers characteristics needed in atomic energy and chemical processing fields. Tantalum has found wide application in electronic components.

MECHANICAL PROPERTIES OF COLD WORKED METALS are significantly altered when forming is done at liquid nitrogen temperatures (-321 F). Some early research results: 1) a 20% reduction by drawing at this low temperature produces properties obtainable only by 60% reduction at normal temperatures, and 2) a metal has greater ductility for a given tensile strength when it is formed at this low temperature than when formed at ordinary temperatures.

ELECTRONIC COMPONENTS THAT WITHSTAND HIGH TEMPERATURES—from 900 to 1500 F—are constructed of titanium and special laboratory ceramic parts. Advances were made possible by the development of a high temperature, ceramic-coated, copper-clad wire and the development of ceramic materials with expansion characteristics matching those of titanium.

MERCURY ISOTOPES have been separated photochemically by a technique that may hold the key to more economical processing of nuclear reactor fuels. The technique is based on the fact that every atom in a molecule vibrates to certain wavelengths of light radiation (ultraviolet, visible or infrared). Initial experiments have recorded an enrichment factor of 1.5 for a specific mercury isotope.

Materials BRIEFS

Imperfect Miles
Scientists say that even a so-called perfect metal crystal has 10,000 miles of dislocations in each cubic centimeter, and heavily cold worked metal may have 100 million miles of dislocations per cu cm.

Big Attraction
Magnets, once made only of iron and steel, are now more successfully fabricated from a variety of other alloys. Latest permanent magnet material is a high purity manganese-bismuth alloy.

Hot Storage
If you use paradichlorobenzene for moth protection, either keep your clothes cool or beware of plastics hangers. At 80 F some plastics will soften and melt into clothes in a few months; at 130 F it has happened in a few hours.

Phosphorescent Peeking
Phosphors will give us a much better look at our universe within a short time. A new device utilizes a series of parallel phosphor screens to magnify a telescopic image. It would make the 200-in. Mt. Palomar telescope the equivalent of a 2000-in. telescope.

Twisted Whiskers
Researchers have been able to form metal whiskers so pure that they can be twisted 20 complete revolutions. This degree of twist permits determination of very accurate stress-strain curves.

Whiter Whitewalls
Whitewall tires made of a new synthetic rubber won't turn yellow with age or develop surface cracks. The compound is immune to ozone, said to be the primary cause of whitewall deterioration.

Wearing of the Green
Aluminum industrial roofing and siding products are now being offered in a color other than natural metallic finish. A soft sea green color treatment increases resistance to industrial fumes.

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For added durability and easy cleaning the interior of the van is also fabricated with tough POLYLITE resin. (Three inches of fibrous glass insulation separate the plastic exterior from the POLYLITE interior.) Attractive, permanent color was incorporated in the reinforced plastic sides and top of the 32-foot van at the time of fabrication.

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Men of Materials...

James S. Lunn is president of Lunn Laminates, Inc., and Executive Board member of Society of Plastics Industry. A graduate of West Point in 1930, he served as Lt. Colonel during World War II. A plastics pioneer who developed many "firsts"—Nike radome, sub fairwater, cab and truck bodies, and the world's largest dome—he is also a member of the Plastics Subcommittee of National Security Industrial Assn. and vice president of a chapter of the Society for Advancement of Management.

Lunn says:

"Reinforced plastics are not miracle materials; they should not be oversold."

"Being new and romantic in appeal, reinforced plastics are often regarded as a universal replacement. It is not uncommon for potential users to grow overly enthusiastic while observing a demonstration of phenomenal impact resistance, at the same time forgetting the low flexural modulus.

"The producers as well as the engineers using plastics must clearly realize that reinforced plastics have their limitations. As molders and users become better acquainted with the advantages and disadvantages of reinforced plastics through trial and error, they will come to have more respect for this new material. But at present, a word of caution is necessary—overselling and misapplication will hurt industry in the long run.

"There are many areas for improvement in reinforced plastics. We need better materials, processes and design data, and more experienced personnel in this field. Should such improvements materialize, they will help reinforced plastics along a smooth road to the right applications, avoiding bruising detours.

"Emphasis should be placed on finding applications where reinforced plastics are particularly suitable rather than trying to use them as a solution for almost every materials inquiry. It is good business and it is good engineering to reject the use of reinforced plastics where the material is not practical for the purpose intended."

Latest Design Data on Radiation Shielding Properties of MALLORY 1000 Metal

When you are designing radiation shields for atomic research, radioactive isotope source containers, or similar applications in nucleonics, you can find valuable information on the unique characteristics of Mallory 1000 in this new Bulletin.

A product of Mallory's extensive experience in specialized metallurgy, Mallory 1000 is a high density powder alloy of tungsten, nickel and copper. It has substantially higher efficiency than lead for absorbing radiation.

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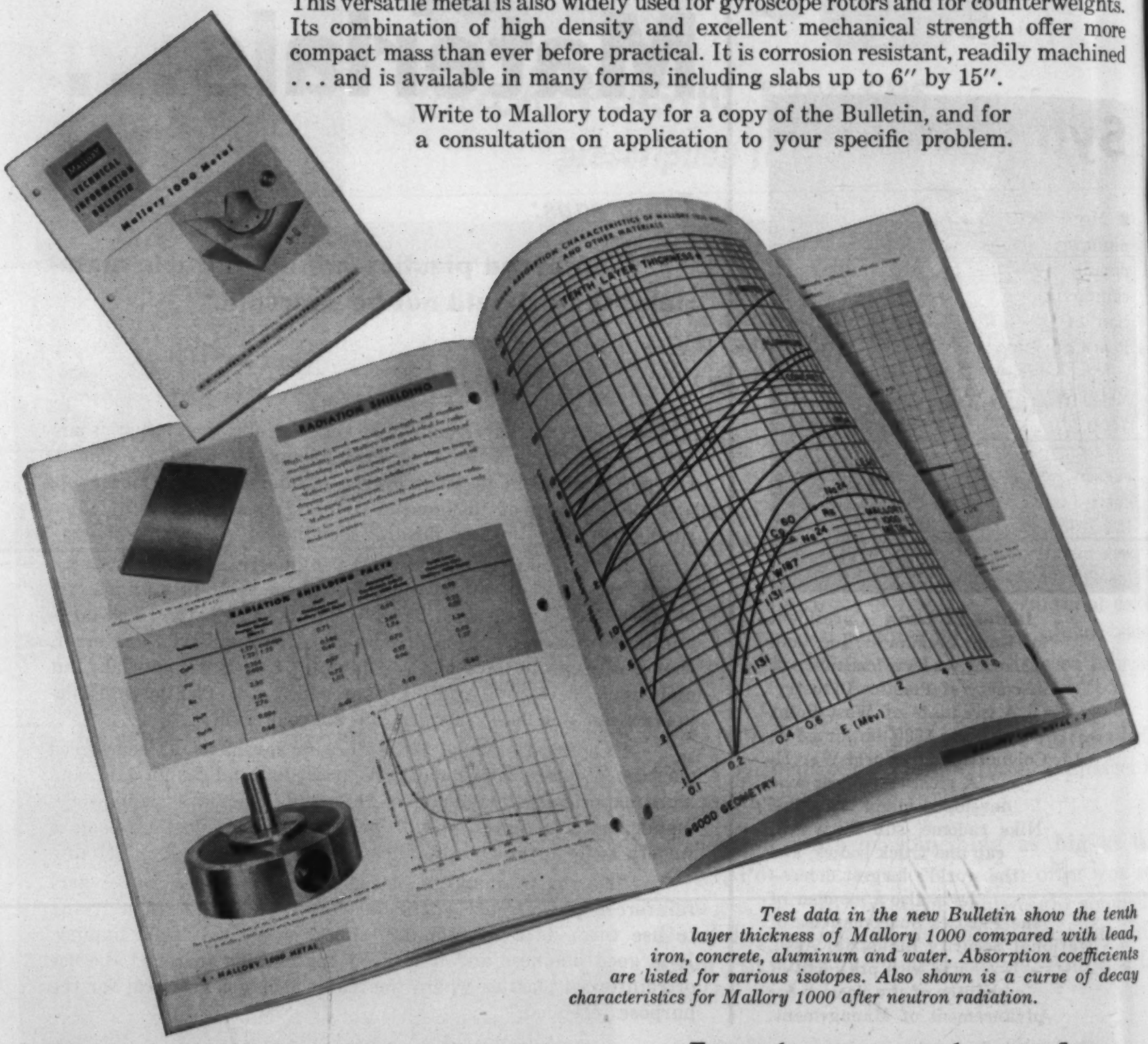

Test data in the new Bulletin show the tenth layer thickness of Mallory 1000 compared with lead, iron, concrete, aluminum and water. Absorption coefficients are listed for various isotopes. Also shown is a curve of decay characteristics for Mallory 1000 after neutron radiation.

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MATERIALS ENGINEERING NEWS

This month

- *Progress in titanium*
- *Basic research developments*
- *Other News starting p 250*

Symposium Reviews Titanium Progress

■ More than 10,000 tons of titanium mill products will be shipped during 1957—double this year's shipments. This was the prediction of Dwight W. Kaufman of Rem-Cru Titanium, Inc., speaking at the second annual Titanium Metallurgy Symposium at New York University.

The course was attended by 180 engineers and executives in industry and government from the U.S., England, and Canada (as well as one representative from the Soviet Union). Lectures were given by 26 leading scientists and engineers.

Mr. Kaufman, in summarizing the rising use of titanium, said in part: "Although other factors are also involved, it is for these two key reasons—high strength-to-weight ratio at elevated temperatures and excellent corrosion resistance—that the growth of the titanium industry has been so rapid in spite of its relatively high cost."

After pointing out the particular uses in specific aircraft, Mr. Kaufman continued: "It is apparent . . . that the major uses thus far have been skins and stiffeners, firewalls, exhaust shrouds and similar parts which are heated by the engine as well as by air friction. . . . In the planes of the future, some of which are now beyond the design stage, as much as 75% of the airframe weight may be titanium. In guided missiles, particularly the long-range ones, titanium is expected to play a very important role. . . .

"In addition to the major role in titanium's development which has been played by the Bureau of Aeronautics, the Navy's Bureaus of Ships and Ordnance have been active in evaluating the metal's use in many applications. Army Ordnance at its laboratories at Watertown Arsenal, has carried out a host of investigations and sponsored many projects which have contributed a great deal of basic knowledge about titanium—its alloys, and fabrication, including casting, and its application. Last, but far from least, are the commercial non-defense uses for titanium. At the present time these consume less than 10% of the industry's production."

Property trends

Speaking from his experience with Armour Research Foundation, D. J. MacPherson stated that "sufficient experience by designers and fabricators with available titanium alloys of reasonably uniform quality is just now accumulating. The properties we now and in the future shall want from titanium alloys must logically be considered on a basis of area of application.

"Perhaps Army Ordnance wants two materials of the desirable density titanium can provide: 1) a plate alloy with greater than 160,000 psi yield strength but with a certain minimum allowable impact strength at —40 F; 2) a plate alloy with maximum possible yield strength with no limitation imposed by impact strength. It is possible that both requirements might be met by different heat treatments of the same alloy or modifications around a given composition. On the other hand, it is likely that the difference in impact requirements would lead to the selection of two very different alloy types. . . .

"Perhaps to justify the use of titanium at all, an airframe concern needs a sheet alloy with a compressive yield strength-to-density ratio that is very high at 900 F, but this sheet must also pass a 3T cold bend requirement. In a very different category—perhaps a complex and intricate casting is needed having only marginal mechanical properties but excellent salt water corrosion resistance. . . .

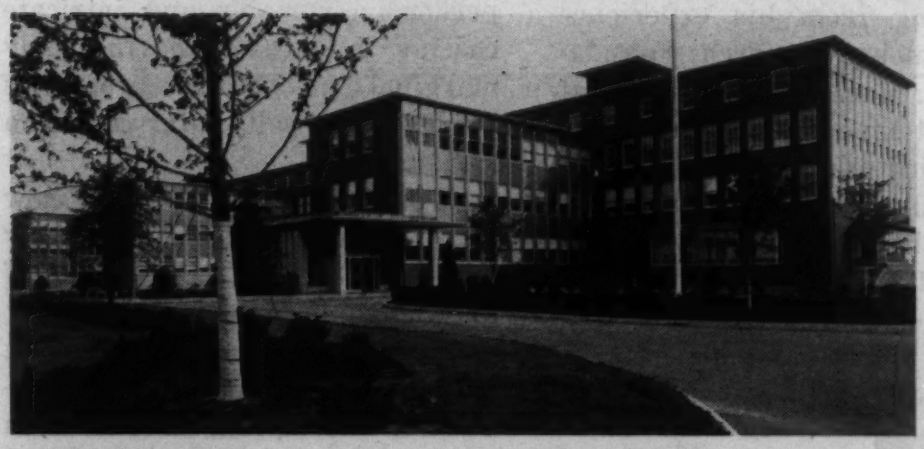
"You can see, I believe, how many specific applications we may have to consider. Our state of knowledge is reaching the point where we can at least select an alloy area for intensive development in attempting to meet such specific needs. One source of property trends in the next few

(continued on p 240)

Basic study—*National Carbon model represents tip of tungsten needle magnified 10^6 times to aid in visualizing electron emission phenomena. Actual study uses field emission microscope to observe heats of absorption and surface mobility as a function of crystallographic plane and to determine the importance of crystalline grain boundaries on the work function of various materials.*

Materials developments in the spotlight as . . .

New Laboratories Expand Basic Research



Westinghouse *research laboratories near Pittsburgh, dedicated last September, provide the electrical manufacturing industry with its most modern research facilities.*

■ Many significant advances in basic materials research projects were revealed recently when both Westinghouse Electric Corp. and National Carbon Co. dedicated multi-million dollar laboratories.

The Westinghouse Laboratories, which replaced a smaller installation nearby, are in the vicinity of Pittsburgh, Pa. The research program will cover chemistry, electromechanics, electronics and nuclear physics, insulation, magnetics and solid state physics, mathematics,

mechanics, metallurgy, physics, semiconductor and solid state physics, and technology. The National Carbon Laboratories at Parma, Ohio, will have a research program embracing solid state physics, electrochemistry, carbon and graphite research, and high temperature refractory compounds.

Both labs held ceremonies which included the announcement of projects completed or under study. Of significant importance in the materials field are these developments:

Westinghouse developments

1. Solventless silicone resins for electrical insulation. These are needed to prevent the formation of voids caused by gassing during curing. The new resins are in such a state that the water of condensation generally given off during silicone curing has already been removed. Previous solventless resins were polyesters which are not suitable for high temperatures.

2. Clad molybdenum alloys that do not crack during forming. Previously, molybdenum clad with oxidation resistant alloys such as Inconel tended to form a brittle layer at the interface. This was overcome by using a thin layer of a third metal, such as platinum, in between.

3. Stronger molybdenum alloys. Alloys having higher stress rupture strength at 1800 F than the 0.5% titanium alloy are being evaluated. They contain 0.25-0.5% zirconium, or up to 2% columbium.

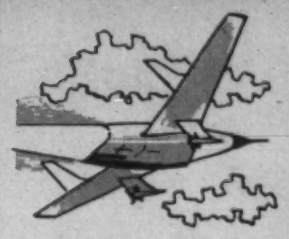
4. New techniques for studying superconductivity of metals. Measurement by heat capacity and by absorption of electromagnetic energy have both been done, but the second was limited by low frequency waves too weak to probe effectively, or high frequency waves with so much energy that they took the electrons out of the superconducting state. Intermediate frequencies (radar) are now being used successfully.

5. Other projects under devel-

(continued on p 242)

***Stainless steel** which will house super-pressure element of new steam turbine is tested inside tanklike electric furnace at Westinghouse. Steam pressure is 16,000 psi at 1200 F. Test is part of program to study behavior of structural metals under extremes of pressure and temperature.*

if you design for...



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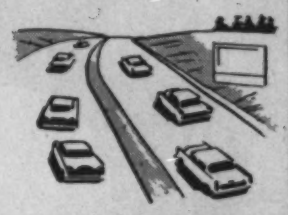

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LETTERS TO THE EDITOR

Why not 'engineers' aides'?

To the Editor:

On the subject of the shortage of engineers—why not have helpers to relieve engineers of time-consuming extra duties?

I first read of the idea recently in connection with the nurse and school teacher shortages. In brief it is this: hire competent engineers' aides, or nonprofessional assistants, who know how to assist engineers and preferably desire to become engineers, to assist licensed engineers by relieving them of time-consuming, nonprofessional duties. Give them work which requires mostly patience and common sense.

The use of nurses' aides has been so successful that the use of engineers' aides ought to be just as successful. In the case of teachers, after a year's experiment with aides they reported: they could handle 50% more pupils; parents felt children had learned more; and kids enjoyed school more.

In these days of abounding engineering activities, which are going to increase astoundingly in the next ten years, why doesn't this plan make sense? Are there any engineering organizations, industries or government agencies trying it or willing to try it?

RAYMOND J. ROSENBERGER
H. K. Ferguson Co.
Cleveland, Ohio

We believe this idea is being tried in some places with mixed results. One report indicates that it is next-to-impossible to find qualified personnel willing to perform such tasks. Do any of our readers have experience with such a plan?

Much ado about thinking

To the Editor:

Thank you for your September editorial, "Let's teach engineers how to think." If more engineers knew how to think effectively, our shortage would not be so acute.

May we urge you strongly to use your publication as a means of presenting an outline of the better known techniques and listing your idea of a useful bibliography? In the meantime, please send us the above data offered by you in your very interesting column, "The Last Word."

N. W.
Chief Engineer

To the Editor:

One of my colleagues has recently called my attention to a very fine editorial, "Let's teach engineers how to think," which appeared in the Sept '56 issue of MATERIALS & METHODS. This article appears at a very opportune time. This semester we initiated a new course to teach engineers the technique of solving total problems and to solve them creatively.

I would appreciate any material you may have on the subject, particularly the bibliography which you mention in another note. If additional copies of your editorial are available to the extent of 15 to 20 copies, I would appreciate them.

It is encouraging to see both colleges and indus-

(continued on p 272)

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Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

MANUFACTURERS' LITERATURE

New Literature

Alloy Die Metal. Advance Foundry Co., 4 pp, illus. Discusses use of chromium-nickel-molybdenum alloy called "Strenes" metal for use in cast-to-shape drawing and forming dies and for machine-finished dies. Includes a list of the alloy's physical properties and a list of the various types of metal avaiable. (1)

Aluminum Dip Brazing. Ajax Electric Co. 7 pp, illus., No. 165. Details how salt bath brazing of aluminum guided missile assemblies at Glenn L. Martin Co. replaced hand welding operation with resultant cost savings and elimination of distortion. Also discusses how the process works and the equipment used. (2)

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Pearlitic Malleable Iron. Albion Malleable Iron Co., 23 pp, illus. Information on metallurgical characteristics, mechanical properties, hardenability, elevated temperature properties and manufacture of pearlitic malleable iron. Also lists specifications on seven grades. (3)

Leaded Steel. Alco Products, Inc., illus, 8 pp. Facts about leaded steel for seamless forged and rolled rings. Physical property data on 11 grades and section sizes of Alco Hi-Qua-Led steel are included. (4)

Rosin Flux. Alpha Metals, Inc., 2 pp, No. 1. Includes description, uses, properties and methods of application of No. 100 Liquid Rosin Flux (nonactivated). Graph shows the concentration-density relationship of Nos. 100 and 400 Flux Thinners. (5)

Aluminum Extrusions. Aluminum Extrusions, Inc., 36 pp, illus. Photographs show the aluminum extrusion process from raw material to finished product. Colored and non-colored extruded aluminum products for various fields of application are also shown. (6)

American Standards. American Standards Assn., 20 pp. Describes the three ways standards become nationally accepted and approved as American Standards. Tells who makes these standards and why, and who uses them. (7)

Brazing Rod. Ampco Metal, Inc., No. W-31. Describes a low-fuming, high strength nickel-brass rod for brazing and braze-welding by the oxyacetylene process. Specification information, applications and size data are given (8)

Steel Tubing. Babcock & Wilcox Co., Tubular Products Div., 6 pp. Two technical data sheets on tubular products, fittings and flanges in various grades of steel. Contains specifications, applications and condensed data on mechanical properties, hot and cold bending, welding, physical properties and heat treatment. (9)

Electrical Contact Materials. Baker & Co., Contact Div., 28 pp, illus. Contact materials, such as silver, platinum, gold, palladium and their alloys, as well as sintered powdered metals, are reviewed in the light of their electrical and physical properties. Typical applications of contacts are included. (10)

Unusual Fabricating Problems. Brooks & Perkins, Inc., 8 pp, illus. Work with magnesium, aluminum, titanium, zirconium, boral, and acrylic plastics is discussed with reference to unusual problems involved in fabricating many parts and assemblies. (11)

Antioxidant. Catalin Corp. of America, 8 pp, illus. Specifications and applications of Antioxidant AC-1 are given. It will protect polystyrene, vinyl films and polyethylene from oxidation and discoloration. It also finds use in pressure-sensitive tapes and insulation. (12)

Chromium Diffusion Coating. Chromalloy Corp., 9 pp, illus. Two bulletins describe advantages and applications of

the Chromalloy process for increasing heat, wear and corrosion resistance of steel parts. Explains Chromalloy case with the use of a photomicrograph. (13)

Metal Powder Shapes. Amplex Div., Chrysler Corp., 52 pp, illus. Engineering manual includes data on properties of Oilite materials and lists Brinell and Rockwell hardness ratings for the materials. A 12-p insert lists over 1000 standard Oilite materials, including sleeve, flange and thrust bearings; cored and solid bar; and plate stock. (14)

Steel Products. Colorado Fuel & Iron Corp., 70 pp, illus. Contains a listing of the company's principal products, including semi-finished and hot rolled steel, heavy and special steel items, rails and accessories, and industrial screens and wire fabrics. (15)

Self-Locking Nuts. Con-Torq, Inc., 14 pp, illus. Information on sizes and prices of self-locking nuts for screw sizes ranging from No. 4 through 5/16 in. Nut sizes, threads per inch, torque limits in inch-pounds and minimum axial tensile values. (16)

Nylon Bobbins, Washers. Cosmo Plastics Co., 4 pp, illus. Maximum and minimum wall thicknesses, core lengths and sizes, as well as flange sizes, for nylon bobbins and washers for a wide range of electrical uses. (17)

Decorative Glass. Croname, Inc., 6 pp, illus. Shows applications of decorative glass. Discusses the four major points designers should know when considering decorative glass for product restyling—3-D decoration, ceramic decoration, cold colors and tempered glass. (18)

Ultrasonic Inspection. Curtiss-Wright Corp., Industrial & Scientific Products Div., 4 pp, illus. Discusses ultrasonic testing, what equipment is involved, and how it may be applied to materials inspection. (19)

Welded Stainless Tubing. Damascus Tube Co., 6 pp, illus. Explains in detail how welded stainless steel tubing is manufactured. Provides answers to a great number of questions often asked about stainless steel tubing. (20)

Grooved Fasteners. Driv-Lok Pin Co., 24 pp, illus. General specifications of grooved fasteners, as well as drilling procedures and hole tolerances for pin applications. Typical applications for various types of fasteners. (21)

Oil Resistance of Rubber. Elastomers Div., E. I. du Pont de Nemours & Co., Inc., 8 pp, illus., No. 69. The June '56 issue of *Neoprene Notebook* discusses the swelling of a rubber compound in oil as a means of measuring elastomer deterioration. (22)

Nonwoven Dacron Felts. E. I. du Pont de Nemours & Co., Inc., Textile Fibers Dept., 14 pp, illus., No. D-78. Gives data on the physical properties of nonwoven felts of 100% Dacron. Includes chemical resistance data as well as data on resilience and heat resistance. (23)

Industrial Laminates. Farley & Loetscher Mfg. Co., Plastics Div., 8 pp, illus. Information on postformed laminates, engraving and nameplate stock, and printed circuit stock. Describes each grade and lists colors and mechanical and electrical properties. (24)

Metallic Bellows. Flexonics Corp., 20 pp, illus., No. 155. Information on applications, design considerations and standards for metallic bellows. Specific details on using bellows manufactured from various metals are included. (25)

Copper-Laminated Plastics. Formica Corp., 16 pp, illus. Explains principles and some of the problems of printed circuitry. Also covers the subjects of plated circuits, plating through holes, flush circuit production and circuit fabricating. (26)

Refractory Mortar. J. H. France Refractories Co., 1 p, illus., No. 610. Contains data on pyrometric cone equivalent, fusion, type of set and estimating data for troweling or dipping applications of the company's new refractory mortar. Specific use recommendations in the steel, glass and nonferrous industries are included. (27)

Plastics Rods, Tubes. Friedrich & Dimmock, Inc., 24 pp. Covers available sizes and prices of rod and tube stock made of clear methyl methacrylate, Teflon, vinyl, polyethylene, cellulose acetate and polystyrene. (28)

Electrical Insulating Materials. Furane Plastics, Inc., 1 p. Chart of formulated epoxy resins giving physical and electrical data on 27 resin systems. Included are room temperature set, heat cured, filled, unfilled, resilient and rigid Epocast resins. (29)

Magnetic Ceramic Cores. General Ceramics Corp., 4 pp, illus., No. MT-104. Graphs show magnetic properties of Ferramic "S-3" ceramic cores. Tables list the various magnetic properties of the cores and give standard core sizes of the parts. (30)

Phenolic Molding Compound. General Electric Co., Chemical Materials Dept. Cure speed, finish, pourability and preformability of GE's 12906 phenolic molding compound are described. (31)

Teflon Finishes. General Plastics Corp., 16 pp, illus. Four bulletins on the nonsticking properties of Teflon—"Non Stick Machine Parts," "Lick Stick with Teflon," "A Report on Teflon," and a bulletin describing the physical properties of Teflon. (32)

Hollow Aluminum Bar Stock. Harvey Aluminum Co., 8 pp, illus. Discusses tolerances, mechanical properties and applications of hollow aluminum bar stock. Case studies and comparison charts. Tables of standard sizes available in round and hexagonal stock. (33)

Permanent Magnet Material. Indiana Steel Products Co., 12 pp, illus. A review of the several characteristics of a permament magnet material that are of special interest to product designers is given in *Applied Magnetics*, vol. 4, no. 3. How the material is used in such fields as electronics and toys is discussed. (34)

Polyester Resins. Interchemical Corp., Finishes Div., 23 pp. Discusses polyester resins for "gunk" molding with respect to their physical properties and method of handling. Explains use of catalysts, mold lubricants and fibrous reinforcement, and offers helpful tips on importance of resin viscosity, mixing equipment and procedures. (35)

High Strength Steels. International Nickel Co., Inc., 29 pp, illus. How strength levels of the basic 4340 nickel-chromium-molybdenum alloy steel can be increased. Specific tests and applications point out the effects of minimum carbon content, lower tempering temperatures, increased silicon content and other variations in composition. (36)

Insulations. Johns-Manville, 20 pp, illus. Information on the composition, physical and thermal properties and sizes of various insulations produced by the company. Covers materials for the efficient control of temperatures from –400 to 3000 F. (37)

Aluminum Alloy. Kaiser Aluminum & Chemical Corp., 8 pp, illus. Outlines the advantages of aluminum alloy 5005 with respect to finishability, anodizing qualities and in-service appearance. Engineering data are presented along with a table showing the alloy's availability in sheet and plate. (38)

Glass Filament Yarn. L.O.F. Glass Fibers Co., 8 pp. Yarn comparison table, listing glass fiber continuous-filament yarn data and equivalent yarn counts of cotton, worsted and rayon. Also, glass yarn nomenclature and manufacturing processes. (39)

Barrel Finishing. Lord Chemical Corp., 40 pp, illus. What the Lorco method of barrel finishing is and how it operates is explained. Includes an application index of barrel finishing compounds. Plastics deflashing, deburring and finishing is also discussed. (40)

Cerium. Mallinckrodt Chemical Works, 6 pp, illus. Discusses the use of misch metal (cerium) in nickel and high nickel alloys, in magnesium for elevated temperature service and in nodular iron and stainless steels. Gives suggested applications. (41)

Heat Resistant Castings. Michigan-Standard Alloy Casting Co., 16 pp, illus. Information on alloy compositions, their properties and limitations, stabilizing influences and heat treatment. Tables list typical room temperature, high temperature and corrosion resisting properties. Stability of the castings in various media such as acid mine water and alkaline salts is included. (42)

Coated Abrasives. Minnesota Mining & Mfg. Co., 10 pp, illus. Case history presentations of several abrasive operations, including prefinishing, weld grinding and blending, removing imperfections, and finishing and polishing. (43)

Urethane Coatings. Mobay Chemical Co., 65 pp, illus. Evaluates components of urethane coatings. Formulation and application of urethane coatings is also discussed in detail, as are cleaning of equipment and handling precautions. (44)

Manufacturers' Literature

Fiberglas Products. Owens-Corning Fiberglas Corp., 132 pp, illus. Includes descriptions of Fiberglas pipe, duct, equipment and cold storage insulations, as well as Kaylo pipe and block insulations. Application details, recommended thicknesses and heat gain, multiple layer combinations, operating temperatures and engineering data. (45)

Cellulose Wadding. Cel-Fibe Div., Personal Products Corp., 8 pp, illus. Outlines the use of Cel-Fibe cellulose wadding for stitched and stitchless sealing to plastics and other facings, in furniture and appliance production, and in filtering applications. (46)

Spring Steel Lockwashers. Pioneer Stamped Products Co., 4 pp, illus. Explains use of the company's line of spring steel lockwashers in various industrial applications and shows the advantages of this washer (47)

Nylon Pressure Tubing. Polymer Corp. of Pennsylvania, 24 pp, illus. Case histories show application of nylon pressure tubing in the automotive, metalworking and furniture industries. How to determine burst strength, comparison with other tubings, suggested fittings, how to cut it and how it is tested. (48)

Copper-Base Alloys. Riverside Metal Div., H. K. Porter Co., Inc., 36 pp, illus. Specifications and applications for phosphor bronze, nickel silver, beryllium copper and cupro nickel are given. Also contains weight tables for sheet, strip, rod and wire; gage and decimal equivalents; definitions of trade terms; and a discussion of temper. (49)

Barrel Finishing. Almco Div., Queen Stove Works, Inc., 52 pp, illus. First section outlines how company's barrel finishing method operates and discusses company research facilities and sample processing procedures. Second section lists barrels, equipment and supplies manufactured by company. (50)

Aluminum Data. Joseph T. Ryerson & Son, Inc., 8 pp, illus. Information on aluminum plates, sheets, coils, rods and bars in stock. A guide to selection of flat rolled aluminum and characteristics of rods and bars are included. (51)

Rare Earths. St. Eloi Corp., 4 pp. Includes latest data on the rare earths, showing the element, its atomic number and weight, its density, oxide formula and weight, color, oxide density and melting point. Price schedules. (52)

Set Screws. Set Screw & Mfg. Co., 28 pp. Catalog of standard set screws and many special types designed to meet conditions of vibration, close precision setting, resistance to tampering and chemicals or heat. (53)

Resins. Shawinigan Resins Corp., 4 pp. Catalog of the company's line of resins listing tradename and chemical name for each resin. Discusses applications in adhesives, coatings, paints, textiles and paper. (54)

Aircraft Fasteners. Standard Pressed Steel Co., 16 pp, illus. Two pamphlets. One on bolts gives tension-tension fatigue charts, tensile and shear strength graphs, and complete specifications for all size ranges. The other on locknuts gives complete specifications for all sizes. (55)

Welded Tubing. Standard Tube Co., 8 pp, illus. Information on stainless steel pipe and tubing; mechanical steel tubing; and boiler, condenser and other pressure tubing. Gives data on sizes and thicknesses and lists applicable specifications. (56)

Hard and Resin Rubbers. Stokes Molded Products, 4 pp. Contains detailed application and property charts and technical molding tolerances for hard and resin rubbers. Guide to selection of compounds to meet general needs. Design considerations. (57)

Magnesium, Aluminum Castings. Superb Light Alloys, Inc., 8 pp, illus. Shows the various operations of this foundry. (58)

Steel Tubing. Superior Tube Co., 6 pp. Two releases describe the company's line of standard and special tubing. Data Memorandum No. 1 lists 121 metals and alloys for standard and special tubing, while Data Memorandum No. 2 describes super pressure tubing. (59)

Brass, Bronze, Aluminum Forgings. Titan Metal Mfg. Co., 32 pp, illus. Design, properties and applications of brass, bronze and aluminum hot-pressed forgings. Factors of strength, core size, flash line and dimensional tolerances are discussed and illustrated. (60)

Monomers. Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp., 4 pp, No. F-40033. Lists 36 monomers and gives their physical properties and uses. Polymers and copolymers prepared from these monomeric compounds are used in the manufacture of surface coating materials, adhesives and synthetic fibers. (61)

Expanded Polystyrene. Uni-Crest Div., United Cork Companies, 4 pp, illus. Describes properties and applications of a new polystyrene, pioneered and developed in Germany and manufactured under license by the Uni-Crest Div., United Cork Companies. The material is available either as a lightweight expanded board or slab or as unexpanded granules ready for molding. (62)

Plywood. U. S. Plywood Corp., 10 pp, illus. Two pamphlets. One deals with a porcelain-faced plywood panel for exterior and interior applications and the other deals with the properties of "Novoply," a three-ply, sandwich-type laminate manufactured from resin-treated wood particles. (63)

Thermoplastic Sheet. U. S. Rubber Co. 12 pp, illus. Offers examples of the practical and profitable applications of "Royalite," a thermoplastic sheet made from a plastics copolymer and synthetic rubber. Lists availability, forming methods and physical properties. (64)

Protective Coatings. U. S. Stoneware Co., Plastics & Synthetics Div., 30 pp, illus. Presents paint data in the form of charts, tables, diagrams and illustrations. Limitations of each coating are given and over-all cost factors relating to specialized coatings are discussed. (65)

Capillary Tubes. Wolverine Tube Div., Calumet & Hecla, Inc., 4 pp, illus. Covers the advantages of plug drawn capillary tubes for metering flow of liquids and gases. How the tubes find use in such industries as refrigeration and air conditioning. Includes specifications on composition, size, length and tolerances. (66)

Other Available Literature

Irons & Steels • Parts • Forms

Special Steels. Allegheny Ludlum Steel Corp., 16 pp. Data on stainless steel, electrical materials, Carmet carbide materials and tool steels. Also charts on analyses of various steels. (73)

Sintered Stainless Parts. Alloy Metal Powders, Inc., 4 pp. "Operational Steps in Producing Sintered Parts From Stainless Steel Powders." (74)

Heat Resistant Castings. American Brake Shoe Co., Electro-Alloys Div., 16 pp, illus., No. T-225. How properties of Thermalloy make it advantageous for castings used in heat treating applications. (75)

Forged Steel Rings, Flanges. Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., 12 pp, No. 10,000. Design advantages and cost-cutting applications of forgings in industrial processing equipment. (76)

Chains. Bead Chain Mfg. Co., 12 pp, illus. Bead chain characteristics and applications are described. (77)

Low Alloy Steel. Bethlehem Steel Co., 66 pp, illus., No. 353. Properties and features of Mayari-R steel for use in applications requiring high strength and good wear and corrosion resistance. (78)

Wire Cloth. Cambridge Wire Cloth Co., 4 pp, illus. New quarterly house organ on woven wire conveyor belts, industrial wire cloth and other woven wire products. (79)

Chromium-Nickel Alloy Steels. Carpenter Steel Co., 14 pp, illus. Carpenter No. 158 for case-hardening jobs and No. 5-317 for tough-tempering and hard-tempering jobs simplify selection problem and meet mechanical requirements for structural applications. (71)

Steel Tubing. Summerill Tubing Co., Div. Columbia Steel & Shafting Co.,

8 pp, illus. Cold drawn steel tubing for hydraulic applications. (80)

Circular Steel Shapes. Commercial Shearing & Stamping Co., 24 pp, illus., No. P-3. Covers range of cold formed circular steel blanks, flanged and dished shapes, produced from stock dies. (81)

Stainless Steel Castings. Cooper Alloy Corp., 8 pp, No. 55. Information on cast stainless steel includes mechanical properties and extensive corrosion data. (82)

Perforated Steel Sheets. Cross Engineering Co., leaflet, illus. Shows variety of designs available and typical uses of perforated steel sheets for ventilation, concealment, decoration and protection. (83)

Powder Metal Parts. Dixon Sintaloy, Inc., 4 pp, illus. Describes facilities for producing powder metal parts. (84)

Forging Information. Drop Forging Assn., 8 pp, illus. Booklet describes forging process and uses of method in everyday products. (85)

Static and Centrifugal Castings. Duraloy Co., 16 pp, illus., No. 3354-G. Describes facilities for producing high alloy static and centrifugal castings. Data on castings for heat, corrosion and abrasion resistance. (86)

Metal Powder Parts. American Sinterings Div. of Engineered Plastics, Inc., 4 pp, illus. Facilities for fabrication of ferrous or nonferrous metal powder parts. (87)

Metal Stampings. Geometric Stamping Co., 4 pp, illus. Suggestions for cost savings through conversion from castings to stampings. (88)

Steel Extrusions. H. M. Harper Co., 16 pp, illus. Covers production of extrusions from stainless steels, heat resistant alloys, titanium alloy steels, carbon steels and specialty bronzes. Glass lubricant assures inexpensive dies, and economical extrusion of difficult alloys. (89)

Machine Part Castings. Hunt-Spiller Mfg. Corp., 20 pp, illus. Gun iron castings of 100% pearlitic microstructure. (90)

Powder Metal Parts. Keystone Carbon Co., 6 pp. folder. Describes powder metal products and production facilities. (91)

Steel Bar. La Salle Steel Co., 20 pp, illus. Data and charts on properties of a high strength, free machining bar. (92)

Carbon and Alloy Steels. Lukens Steel Co., 12 pp. Compares carbon and alloy steels for pressure vessels. Nine graphs show temperature limitations. (93)

Threaded Stampings. Mohawk Mfg. Co., 2 pp, No. 851. Illustrates variety of products produced by Mohawk's stamping processes, which guarantee uniform threaded parts. (94)

Stainless Steel Castings. Ohio Steel Foundry Co., 4 pp, illus., No. 651-C. Compositions of Fabrite stainless steels for casting and illustrations of numerous corrosion resistant castings. (95)

Small-Mesh Expanded Metal. Penn Metal Co., Inc., 4 pp, illus. Sizes, dimensions and weights of Minimesh, a small mesh expanded metal used for guards or grilles on stoves, heaters, radios and coin-operated phonographs. (96)

Seamless Mechanical Tubing. Pittsburgh Steel Co., 198 pp, illus. Applications, cost analysis, production techniques, inspection methods, tolerances, and reference tables for seamless mechanical tubing. (97)

Precoated Strip. Thomas Strip Div., Pittsburgh Steel Co., 18 pp, illus. Strip steel electrolytically and hot dip coated with zinc, copper, brass, lead alloy, nickel or chromium with or without rolled-in patterns. Includes 10 sample disks of coated strip. (98)

Custom Steel Parts. Henry Disston Div., H. K. Porter Co., Inc., 16 pp, illus. Describes custom steel parts, how they are made and how to use and order them. (99)

Deep Drawn Parts. Pressed Steel Tank Co., 16 pp, illus. How industries have been helped in quality production at low cost by use of Hackney Metal containers and deep drawn component parts. (100)

Roll Formed Shapes. Roll Formed Products Co., 26 pp, illus. Shows simple and complex sections produced from both ferrous and nonferrous metals. (101)

Wire Processing. Sylvania Electric Products, Inc., Parts Div., 12 pp, illus. Facilities for manufacture of fine wire and ribbon, and wire and ribbon parts. Chemical composition charts of materials used are included. (102)

Steels. Timken Roller Bearing Co., Steel & Tube Div., Canton, Ohio. Complete catalog of steels. Request from Timken on company letterhead.

Small Precision Metal Parts. Torrington Co., Specialties Div., 4 pp, illus. Shows various small precision metal parts custom-made by this company. (103)

Stainless and High Alloy Tubing. Trent Tube Co., 48 pp, illus. Classifies types of tubing, giving typical applications, physical, chemical and electrical properties for each. Information on welding, bending and installation. (104)

Fine Seamless Tubing. Uniform Tubes, 4 pp, illus. Covers a complete line of fine seamless tubing available in sizes from 0.10 to ⅝ in. o.d. and in metal of almost any analysis. (105)

Steel Castings. Unitcast Corp., illus., No. 649A. Discusses testing facilities for insuring high quality production of steel castings. (106)

Stampings. WLS Stamping Co., 4 pp, illus. Describes high speed, low cost stamping process using "speed tooling" method. (107)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 67 and 68.

Pipe and Tubing. Wallingford Steel Co., 8 pp, illus. Stainless, carbon and alloy steel tubing for ornamental, mechanical, pressure, sanitary and aircraft use in size range from ¼ to 3 in. o.d. (108)

Stainless Steel Castings. Waukesha Foundry Co., 4 pp, illus., No. WF-5. Facilities for producing any hard-to-shape type of stainless steel castings. (109)

Powder Metal Products. Yale & Towne Mfg. Co., Powdered Metal Products Div., 16 pp, illus. How Powdermet parts permit close tolerances, good wearability, controlled porosity and high ductility. (110)

Mechanical Tubing. Youngstown Sheet & Tube Co., 4 pp, illus. Features size and wall thickness of a complete line of Yoloy electric weld mechanical tubing. (111)

Nonferrous Metals • Parts • Forms

Aluminum Design Manual. Aluminum Co. of America, 32 pp, illus. Describes Alcoa impacts and impact extrusion which produces hollow cup-shaped shells, flanged or cupped-end tubes, solid shapes and combinations of these forms. (117)

Prefinished Metals. American Nickeloid Co., 24 pp, illus. Describes fabrication techniques, uses and properties of prefinished metals. Also gives case histories of applications in various manufacturing fields. (118)

Bronze Electrodes. Ampco Metal, Inc., 4 pp, illus., No. W-25a. Applications, characteristics, properties and sizes of Ampco-Trode electrodes, both a.c. and d.c. (119)

Magnesium - Thorium Alloy. Brooks & Perkins, Inc., 28 pp. Design data on the new temperature resisting magnesium alloy, HK-31. Graphs and charts. (120)

Bimetals. W. M. Chace Co., 36 pp, illus. Describes and explains 22 uses of bimetals as actuating elements in temperature responsive devices. (148)

Brass Die Pressed Forgings. Chase Brass & Copper Co., 4 pp, illus. Three-dimensional photographs show the difference between the same articles made as die pressed brass forgings and as brass sand castings. (121)

Machining Titanium. Cincinnati Milling Machine Co., 16 pp, illus., No. M-1866. Discusses machining characteristics with emphasis on chip formation. (122)

Refractory Molybdenum Borides. Climax Molybdenum Co., 6 pp, No. Cdb-8. Applications, properties and preparation of six molybdenum borides. (123)

Precision Investment Castings. Crucible Steel Co. of America, 16 pp, illus. How to precision-cast unmachinable high-temperature alloys to close tolerances through "lost wax" method. (124)

Aluminum Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy 40-E, a high strength alloy containing zinc, magnesium, titanium and chromium. Alloy needs no heat treatment. (125)

Electrical Contacts. Gibson Electric Co., No. C-520. Technical data on contacts

Manufacturers' Literature

and contact assemblies to fit the needs of an electrical or electronic product. (126)

Investment Castings. Hitchiner Mfg. Co., 12 pp, illus. Description of precision investment casting and its advantages and limitations. (127)

Investment Castings. Investment Casting Co., 12 pp, illus. Second edition explains how investment casting is used to eliminate machining and assembly costs and minimize waste metals. (128)

Aluminum Extrusions. Kawneer Co., Aluminum Mill Products Div., 4 pp, illus. Describes completely integrated (pig through extrusion) facilities for producing shapes, rod, bar and tubing. (129)

Die Castings. Lester Castings, Inc., 4 pp, illus. Shows facilities for producing die castings. (130)

Lithium Metals, Compounds. Lithium Corp. of America. Data sheets on properties and uses of lithium metal and organic and inorganic lithium compounds for metal treatment and ceramic modifications, welding. (131)

Alloy Metals. Littleford Bros., Inc., 4 pp, illus. Facilities for fabricating large assemblies and small parts for various metal alloys. (132)

Thermostat Metals. Metal & Controls Corp., General Plate Div. Information on selecting thermal elements. Tables give major mechanical and physical constants for various thermostat metals. (133)

Titanium. Metal Hydrides, Inc., 2 pp, No. 600-C. Data sheet on titanium metal and facts on storage and handling. (134)

Precious Metal Wire. J. M. Ney Co., 2 pp. Technical data on Ney-Oro 6, precious metal wire for pivots in instrument bearings. (135)

Die Castings. Paramount Die Castings Co., 4 pp, illus. Describes facilities and services. Also shows representative aluminum, magnesium and zinc castings. (136)

Die Castings. Parker White Metal Co. Engineering data on die cast component parts. (137)

Copper Tubing. Penn Brass & Copper Co., 6 pp, illus. Features of this company's seamless copper tubing. Includes tables of safe internal working pressures of various tubing sizes. (138)

Die Castings. Precision Castings Co., Inc., 24 pp, illus. Describes integrated facilities for quantity production of aluminum, magnesium and zinc die castings. (139)

Titanium and Its Alloys. Republic Steel Corp., 32 pp, illus., No. 588. A practical working manual presenting some basic data on commercial quality titanium and its alloys. (140)

Aluminum Products. Revere Copper & Brass, Inc., 35 pp, illus. Lists products and applications and includes tables on alloys available. (141)

Aluminum Digest. Reynolds Metals Co., 2500 S. Third St., Louisville 1, Ky. *Reynolds Aluminum Digest* contains 50 to 60 reviews of articles relating to aluminum, a news summary of related current events, and statistics on the aluminum industry. To receive this monthly, request from Reynolds, Desk ES.

Metal Designs. Rigidized Metals Corp., 2 pp, illus. Folder contains four metal samples. Company has more than 40 standard patterns. (142)

Centrifugal Castings. Sandusky Foundry & Machine Co., 6 pp, illus. Specification chart for ferrous and nonferrous alloys for centrifugal castings. (143)

Zinc Die Castings. St. Joseph Lead Co., 25 pp, illus. Discusses role of zinc as a base metal for die casting alloys and lists the variety of commercial finishes for zinc base die castings. (144)

Light Metal Castings. Thompson Products, Inc., Light Metals Div., 8 pp, illus. Describes a complete line of precision die castings for various industrial uses. (145)

Bimetallic Construction. Arthur Tickle Engineering Works, 8 pp, illus. Describes Alumibond process for molecularly bonding aluminum and its alloys to iron and steel and their alloys. (146)

Sintered Bearing Alloys. U. S. Graphite Co., Div. of Wickes Corp., 6 pp, illus., No. 18. Discusses design and metallurgical requirements for selection of sintered metal bearings. (147)

Nonmetallic Materials • Parts • Forms

Flexible Tubing. American Hard Rubber Co., 4 pp, illus., No. 66-D. Physical properties, chemical resistance, standard sizes and characteristics of transparent plastic tubing. (152)

Extruded Plastics. Anchor Plastics Co., 12 pp, illus. Applications of thermoplastic rods, tubes and shapes. Summary of properties of plastics materials with usage table. (153)

Fiberglass - Reinforced Plastics. Apex Electrical Mfg. Co., 4 pp, illus. Case histories of custom molded fiberglass parts featuring pressure vessels. (154)

Nonmetallic Linings. Automotive Rubber Co. Eleven actual specimens of rubber and plastics compounds used in corrosion and abrasion resistant lining work done by the company on tanks, pipe, fittings, duct work, fans and other equipment. (155)

Porous Media. Carborundum Co., Refractories Div., 55 pp, illus. Data on Aloxite aluminum oxide porous media for various applications. (156)

Clear Rigid Plastics. Cast Optics Corp., 12 pp, illus. Lists uses, advantages and properties of five optically clear rigid plastics sheets. Also explains engineering service. (196)

Resin - Bonded Laminates. Chemical Corp., 20 pp, illus., No. PD-1R353. Data sheets on a variety of tanks, ducts, hoods, stacks and waste pipe for corrosion resistant use. (157)

Fiberglass-Reinforced Parts. Clearfield Plastics, Inc., 22 pp, illus. Facilities for producing molded contoured parts. Suggests design and specification techniques. (151)

Pipe and Fittings. Colonial Plastics Mfg. Co. Series of bulletins describing pipes and fittings made of rigid unplasticized polyvinyl chloride. Also data on valves. (158)

Extruded Plastics, Rubber. Conneaut Rubber & Plastics Co., 4 pp, illus., No. CR-53. Die making and production facilities for rubber and plastic extrusions. (159)

Silicone Rubber. Connecticut Hard Rubber Co., 8 pp. Lists silicone rubber's outstanding properties and describes an extensive line of distributor handled stock items. (160)

Teflon Products. Continental-Diamond Fiber Co., Div. of Budd Co., Inc., 16 pp, illus., No. T-55. Catalog of Teflon tubes, sheets, rods, gaskets and fabricated specialties. (161)

Glass. Corning Glass Works, 12 pp, illus., No. IZ-1. Stresses increasing importance of glass in product design, tabulates physical characteristics of various glasses and describes design services. (162)

Honeycomb Material. Douglas Aircraft Co., Inc., Aircomb Section. Development of Aircomb, a honeycomb structure of Kraft paper impregnated with a phenolic resin. It is said to be fire resistant, pest resistant and an excellent insulator. (163)

Teflon-Coated Glass Fabrics. E. I. du Pont de Nemours & Co., Fabrics Div., 4 pp. Electrical, mechanical, chemical, thermal and forming properties of Teflon-glass fabrics, as well as toxicity precautions and suggested uses. (164)

PVC Pipe. Easton Plastic Products Co., Inc., 9 pp. Three bulletins: chemical resistance of Easton polyvinyl chloride pipe; specifications on pipe and fittings; and instructions for threading, cutting and assembling PVC pipe and fittings. (165)

Electroformed Molds. Electromold Corp., 4 pp. Gives details of electroforming process for plastics molds. (166)

High Impact Plastics. Fiberite Corp., 4 pp, illus. Describes largest producer of reinforced phenolic and melamine molding compounds, gives properties of various Fiberite materials and shows applications. (167)

Synthetic Rubber. Firestone Tire & Rubber Co., Synthetic Rubber & Latex Div. Information on FR-S, a new synthetic rubber developed by improved techniques, new measuring devices and scientific methods of control. (168)

Graphite. Graphite Specialties Corp., 4 pp, No. GS 101-1. An impervious graphite, more than 99.5% pure carbon, for high temperature parts. Chemical resistance data and physical properties, including heat effects to 5700 F, are charted. (169)

Polyvinyl Chloride. N. Hartwell & Son, Inc., 6 pp, No. 4B. Facts about Boltaron PVC used for sheets, bar stock, pipe fittings, pipe blocks, welding rod and valves. (170)

High Density Polyethylene. Hercules Powder Co., Cellulose Products Dept., 6 pp. Properties and uses of Hi-fax, a new high density polyethylene made by the Ziegler process. (171)

Adhesives and Coatings. Houghton Laboratories, Inc., 96 pp. Bound volume of technical bulletins covering adhesives, coatings and plastics materials. (172)

Rigid Polyvinyl Chlorides. Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., 6 pp. Chemical and physical properties of Vyflex rigid polyvinyl chloride plates and sheets. (173)

Cemented Carbides. Kennametal, Inc., 44 pp, illus., No. B-222. "Designing with Kennametal" provides mechanical design information for engineers who design parts calling for the use of Kennametal or Kentanium. (174)

Glass. Libbey-Owens-Ford Glass Co., 8 pp, illus. Glass in product and engineering design. (175)

Refractory Porcelain. McDanel Refractory Porcelain Co., 36 pp, illus. Catalog of high temperature porcelain products with physical, mechanical and electrical properties. (176)

Alkali Hardwood Lignin. Mead Corp., 14 pp. Outlines properties, industrial applications and chemical modifications of "Meadol." (177)

Fire Resistant Hydraulic Fluid. Monsanto Chemical Co., 20 pp. Describes hydraulic fluid that reduces fire hazards and has operating qualities of petroleum fluid. (178)

Carbon Parts. Ohio Carbon Co., 4 pp, illus. Thermal, mechanical and electromechanical properties of company's carbon parts. (179)

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. (180)

Polyester Resins. Reichhold Chemicals, Inc. Brochure includes 11 technical bulletins describing Polylite line of liquid thermosetting polyester resins suitable for use in glass fiber reinforced applications. (181)

Gasket Materials. Rogers Corp., 12 pp. Recommendations for using Duroid gasket materials. Also data sheets on seven specific gasket sheeting materials, which include typical test values and service recommendations. (182)

Paper Chemicals. Rohm & Haas Co., 2 pp. Revised price list for paper chemicals incorporating reductions in price of several products. (183)

Adhesives for Plastics and Metals. Rubber & Asbestos Corp. Data chart lists technical data, form, percent solids, average viscosity, curing time and temperature and applications for 30 adhesive formulations used in bonding plastics to metals. (184)

Flexible Teflon Tubing. Sparta Mfg. Co., 4 pp. Properties and characteristics of Teflon thin-walled and spaghetti tubing. Suggested uses include: instrument tubing, electronic applications, wire sheathing and high temperature lines. (185)

Ceramics Insulation. Star Porcelain Co., 3 pp. Specifications on center shoulder bushings, insulating washers and bushings made of steatite ceramic. (186)

Polyurethane Foam. Surface Chemicals, Inc., 4 pp. Properties of Isothane foam for thermal insulation and sound control. (187)

Cathodic Protection. National Carbon Co., Div. Union Carbide & Carbon Corp., 12 pp, illus., No. S-6500. How to mitigate corrosion of underground and submerged metal structures by application of an impressed current cathodic protection system using graphite anodes. (188)

Tetrafluoroethylene. U. S. Gasket Co., No. 300. Tables and descriptive matter on chemical, electrical, thermal and mechanical properties of Teflon. (189)

Metal-Plywood Laminate. U. S. Plywood Corp., 8 pp, illus. Gives special features, advantages and wide variety of uses for Armoply, sheet metal-bonded plywood. (190)

Vinyls and Polyesters. Naugatuck Chemical Div., U. S. Rubber Co., 8 pp, illus. Vinyl, polyester and elastomeric resins and compounds, applications, properties and processing. (191)

Plastics Pipe. National Tube Div., U. S. Steel Corp., 28 pp, illus., No. 24. Data on unplasticized rigid polyvinyl chloride pipe, both normal and high impact types. Describes installation techniques. (192)

Flexible Plastics Tubing. U. S. Stoneware Co., 28 pp, illus. Properties and uses of extruded vinyl plastic tubing available in semi-rigid or flexible sheets, tubing or solid cord. (193)

Felt. Western Felt Works, 28 pp. Discussion of felt, its applications, composition, specifications and testing methods. (194)

Extruded Plastics. Western Textile Products Co., Extruded Plastics Div., 4 pp, illus. Describes company experience in extrusion and shows special problems solved. (195)

Finishes • Cleaning & Finishing

Dispersions. Acheson Colloids Co., Div. of Acheson Industries, Inc., 4 pp. Lists 41 colloidal and semi-colloidal dispersions for operational functions, maintenance, and other industrial applications. (199)

Chromate Conversion Coatings. Allied Research Products, Inc., 4 pp, illus., No. 8. Complete data on the basic characteristics of Iridite chromate conversion coatings and their functions on various metals. (200)

Plastics Finish. John L. Armitage & Co., 8 pp. Information on Armorhide. a textured plastics finish resembling leather. (201)

Barrel Finishing. Abbott Ball Co., 8 pp, illus. Describes barrel finishing techniques with a new design tumbling barrel. (202)

Protective Coatings. Ceilcote Co., 8 pp, illus., No. C-150. Gives base formulations, chemical properties and adhesion characteristics of seven standard organic coatings. Includes simplified chart for selecting coatings. (203)

Chromium Plating. Dawson Corp., illus. Describes packaged chromium plating plant designed for precision control of dimensional build-up or salvage of wear components, tools and gages. (204)

Black Oxide Finish. Du-Lite Chemical Corp. Information on finishes for steel blackening. Also information on Du-Lite cleaner, strippers and burnishing compounds. (205)

Paint Wiping, Spraying. Finish Engineering Co., Inc., 4 pp, illus. Data on an automatic paint wiper that handles 1000 parts per hr and a spray painting machine that paints as many as 1200 pieces per hr. (206)

Solution Coating Resin. Firestone Plastics Co., 8 pp, No. 13. Properties and uses of Exon 450 vinyl chloride copolymer resin for solution coatings, either permanent or strippable. (207)

Bright Nickel Plating. Harshaw Chemical Co., 4 pp, illus. Advantages of Nubrite bright nickel plating process. (208)

Colored Silicone Finishes. Midland Industrial Finishes Co., illus. An interesting discussion of the application of colored silicone finishes. (209)

Brushing. Osborn Mfg. Co., 10 pp, illus. Describes advantages of industrial brush finishing operations through case histories. (210)

Metal Finishing. Promat Div., Poor & Co., 4 pp, illus. Explains Pre-Galv process of controlling galvanizing operations by use of only one addition to each of the pickle and flux operations. (211)

Electrostatic Spray Painting. Ransburg Electro-Coating Corp., 16 pp, illus. Typical on-the-line examples of the Ransburg No. 2 process of electrostatic spray painting, which saves paint and reduces rejects. (212)

Porous Chromium Coatings. Van der Horst Corp. of America, 12 pp, illus. Describes oil retaining, wear resistant chromium coating for bearing surfaces, cylinder walls and other applications where hard wear and lubrication are factors. (213)

Methods & Equipment

Induction Furnaces. Ajax Electrothermic Corp., 8 pp, illus., No. 27-B. Induction furnaces for precision melting, heating forging billets and heat treating. Includes selector chart for induction heating and melting applications. (217)

Heat Treating Equipment. American Gas Furnace Co., 140 Spring St., Elizabeth, N. J., 24 pp, illus., No. C-1304. Blow pipes, forges, pot furnaces, brazing and industrial heating machines. Request from American Gas on company letterhead.

Hardness Testers. Riehle Testing Machines, Div. of American Machine & Metals, Inc., 4 pp, illus., No. RH-1154.

To obtain literature listed on these pages, use the convenient prepaid post card on pp 67 and 68.

Manufacturers' Literature

Portable hardness testers for Rockwell readings with scales A, B, C, D, F and G. (218)

Silver Brazing. Amercian Platinum Works, 16 pp. Manual on selective fluxing for low temperature silver brazing. (245)

Test Chambers. American Research Co., 4 pp, illus. Describes basic environmental test chambers for testing under a variety of conditions. (219)

Stainless Fasteners. American Screw Co., 7 pp. Gives physical properties and applications. Describes cold heading and other fabricating techniques. (246)

Radium Radiography. Atomic Energy of Canada, Ltd., Commercial Products Div., P. O. Box 379, Ottawa, Canada, 71 pp, illus, price $2.00. Detailed theory, equipment and applications of radium radiography. Available directly from Atomic Energy of Canada.

Black Light. Black Light Corp. of America, 65 pp, illus. Long wave ultraviolet light for industrial inspection and flaw detection. Case histories plus data on research in this field. (247)

Bolts, Nuts, Screws. Buffalo Bolt Co., Div. of Buffalo Eclipse Corp., 101 East Ave., North Tonawanda, N. Y., 150 pp, No. 51. Guide for purchasing bolts, nuts and screws. Includes blueprints, specifications and prices. Request from Buffalo Bolt Co., on company letterhead.

Injection Molding Cellulosics. Celanese Corp. of America, Plastics Div., 7 pp, illus., No. A-16. "Fundamentals of Injection Molding Cellulosics." (216)

Chrome-Moly Electrode. Champion Rivet Co., 13 pp, No. CM-55. Low hydrogen welding electrodes for chromium molybdenum alloy steels. Includes physical and mechanical properties of welds, chemical analysis of weld deposit and a discussion of welding procedure. (220)

High Vacuum Equipment. Consolidated Vacuum Corp. Price list of high vacuum equipment, accessories. (221)

Nondestructive Sorting. J. W. Dice Co., 1 p, illus., No. 2007. Describes Model CE Cyclograph for nondestructive sorting of mixed metals of metallurgical characteristics. (222)

Explosive Rivets. E. I. du Pont de Nemours & Co., Inc., Explosives Dept., 32 pp, illus., No. A-2281. Complete data on two types of explosive rivets—high speed industrial explosive rivets and aircraft explosive rivets. (223)

Industrial Radiography. E. I. du Pont de Nemours & Co., Inc., Photo Products Dept., 24 pp, illus. X-ray films, chemicals and screens for industrial radiography. Charts evaluate basic characteristics of Du Pont x-ray films and give optimum processing recommendations. (224)

Projection Gaging. Eastman Kodak Co., 12 pp, illus. Describes four models of the contour projector and their accessories for inspection usage. (225)

Welding Procedures. Eutectic Welding Alloys Corp., 140 pp, illus. Pocket data book containing welding procedures for every base metal. Covers 120 welding rods, electrodes and welding compounds. (248)

Rivet-Type Fasteners. B. F. Goodrich Co., Rivnut Div. Cardboard "demonstrator" illustrates working principle of Rivnuts, their construction and applications. (226)

Lock, Weld and Clinch Nuts. Grip Nut Co., 12 pp, illus. Specifications and applications for Gripco fasteners. (227)

Decimal Equivalent Chart. John Hassall, Inc. Easy-to-read decimal-equivalent wall chart of this company's cold headed parts. (249)

Heat Treating Furnaces. Hevi Duty Electric Co., 8 pp. illus., No. 653. Describes furnaces for annealing, stress relieving, nitriding, etc. (250)

Socket Screws. Holo-Krome Screw Corp., 32 pp, illus. Industrial consumer net price schedule for cold forged socket screw products. (228)

Die Casting Lubricants. E. F. Houghton & Co., 4 pp, illus. Outlines development of die casting lubricants to meet modern high production needs. (229)

Hardness Conversion Tables. International Nickel Co., Inc. Celluloid card, 2¾ x 4¾ in., gives approximate relationship among Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steels. (251)

Tablet Presses. Kux Machine Co., 4 pp, illus. Tableting presses for production of powdered metal and ceramic parts. (252)

Atmosphere Control. Leeds & Northrup Co., 20 pp, illus., No. TD4-620(1). How to control surface carbon content automatically in heat treating steel. (230)

Die Casting Machines. Lester Phoenix, Inc. Features and specifications of die casting machines and injection molding machines. (253)

Welding Electrodes. Lincoln Electric Co., 28 pp, illus., No. SB-1352. Guide for selecting electrodes for stainless steels, nonferrous metals and cast iron. (231)

Electrodes, Holders. P. R. Mallory & Co., Inc., Welding Div., 2 pp, illus., No. 8-11. Advantages, design and application of 8-deg ⅝-dia spot welding electrodes and holders. (232)

Tubular Furnaces. Marshall Products Co., 4 pp, illus. Discusses both the creep test and tensile test models of Marshall tubular furnaces, as well as control panels and radial brackets. (233)

Radiography. Metal & Thermit Corp., 4 pp, illus. Industrial radiography with gamma rays for field and shop work. (234)

Impact Testers for Metals. National Forge & Ordnance Co., Testing Machine Div., 4 pp, illus., No. 561. Describes features of impact testers for metals. These units have convenient controls, do not require skilled operators and conform to ASTM standards. (235)

Induction Brazing. Ohio Crankshaft Co. "Typical Results of Tocco Induction Brazing and Soldering" shows by case histories the advantages of these joining methods. (236)

Pyrometers. Pyrometer Instrument Co., Inc., 8 pp, illus., No. 175. Catalog of optical, micro-optical, radiation, immersion, surface and indicating pyrometers for precision temperature measurements. (254)

Modern Testing. Tinius Olsen Testing Machine Co., 25 pp, illus. Anniversary issue traces major advances in design of testing and balancing equipment since 1880. (237)

Blast Cleaning, Dust Control. Pangborn Corp., 16 pp, illus., No. 226. Describes various models of "Continuous-Flo Rotoblast" barrels available for production line blast cleaning. (238)

Cold Cabinet. Revco, Inc., 2 pp. Low temperature cabinet for industrial processes and research. (239)

Lock Screw Fasteners. Russell, Burdsall & Ward Bolt & Nut Co., 3 pp, illus. Advantages and dimensions of spinlock screws. (255)

Ultrasonic Inspection. Sperry Products, Inc., 8 pp, illus., No. 50-105. Explains principle of ultrasonic inspection and illustrates latest types of equipment. (256)

Heat Treating Equipment. Stanwood Corp., 4 pp. Brief description of types of heat treating equipment with suggested applications. (240)

Metal Powder Press. F. J. Stokes Machine Co., 4 pp, illus. Information on a 50-ton multiple-motion powder metal press. (257)

Preheat Temperatures. Tempil Corp. Chart lists recommended preheat temperatures for 79 commonly used metals and alloys. (260)

Vacuum Forming. Bakelite Co., Div. of Union Carbide & Carbon Corp. Latest issue of *Extruderitems* covers "Extrusion of High-Gloss, High-Impact Styrene for Vacuum Forming." (241)

Brazing Alloys. United Wire & Supply Co., 3 pp, illus. Wire brazing aluminum for low temperature brazing of various metals and alloys. (242)

Inert Gas Welding Process. Westinghouse Electric Corp., Welding Div., 7 pp, No. B-6525. Performance and applications of consumable electrode inert gas welding process. (258)

Perforating Dies. S. B. Whistler & Sons, Inc., 24 pp, illus., No. 55. Catalog of adjustable perforating dies. Lists sizes, shapes, applications and punching pressures. (243)

Electric Radiant Panels. Edwin L. Wiegand & Co., 6 pp, illus., No. CS605. Folder includes a variety of applications of Chromalox electric radiant panels. (259)

Electric Weld Tube Mills. Yoder Co., 64 pp, illus. Reviews tube making processes and gives complete description of the cold forming, electric welding process—its development, its possibilities and its limitations. (244)

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One Point of View:

Why 'niobium'? To users it's still columbium

Deciding what to officially name a metal when two names for it already exist is a difficult problem. And because the decision has far-reaching effects, the choice should be made only after careful consideration of all interests involved. In the renaming of element 41, commonly called columbium in this country, the interests of the engineering profession and the metal industry have certainly been neglected.

How we got 'niobium'

Several years ago the International Union of Pure and Applied Chemistry (IUPAC), in association with the Atomic Weights Commission, adopted the name niobium rather than columbium for this metal. Shortly afterward, the National Research Council and the American Chemical Society concurred in this decision by changing their official designation from columbium to niobium. Since then, pressure on the metals industry to conform to this usage has steadily increased. Thus far the engineers and metallurgists have resisted and have done so for good reasons.

Most authorities will agree that on the basis of historical priority alone, the metal should be called columbium, the name given it by its discoverer, C. Hatchett of England, in 1801. However, according to an IUPAC nomenclature committee member, it was decided that historical priority was only one of many factors to consider in selecting the best name for international adoption.

Users neglected

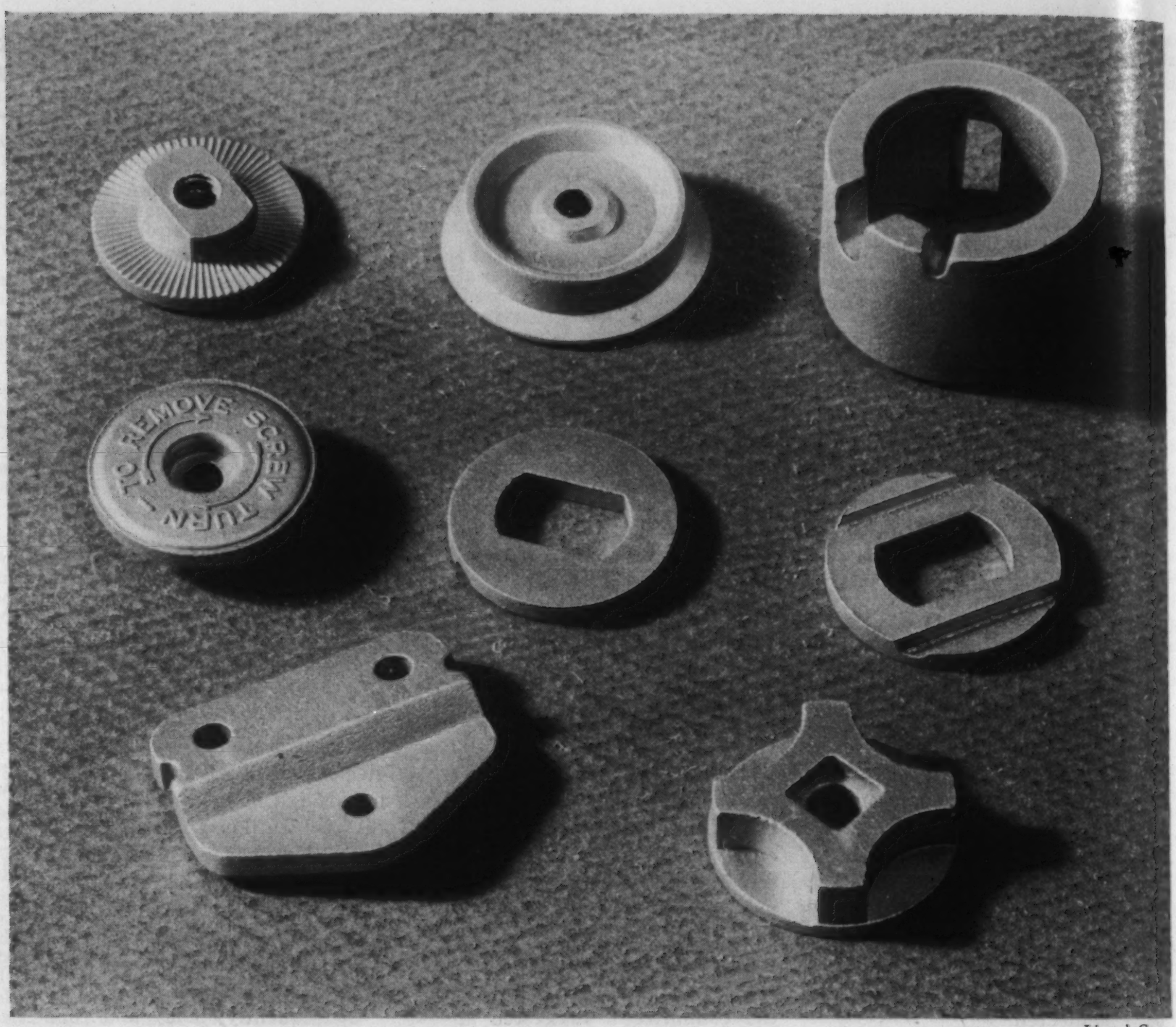
We do not quarrel with the committee's suggested approach, but apparently they themselves saw fit not to follow it. As far as we can determine, the nomenclature committee adopted the name niobium primarily because it is used in all languages except English and in much of the literature on the metal's chemistry.

But columbium is not confined to chemical laboratories and the chemical literature. It is far better known for its use in the metals industry. As far back as the late 1920's, columbium was being actively investigated in this country as an addition to stainless steels to inhibit intergranular corrosion. By 1935 columbium-stabilized stainless steel had become a standard grade (Type 347). Since then, as much as one million pounds a year has been produced in the United States, the greater portion being used in stainless steels. The rest is used as an alloying element in high temperature metals and in welding wire. As far as we know, at present columbium has no other commercial uses, nor is it being used in commercial quantities outside of the English-speaking countries.

Give users a break

Consequently, today and for the last 25 years or so, all specifications, technical bulletins and metallurgical papers refer to this metal as columbium, and these references far exceed the chemical papers and treatises in which the name niobium is used. In addition, the personnel (both technical and nontechnical) in steel producing and metal using industries who would have to be re-educated to accept the new name far outnumber the men directly concerned with columbium in the chemical field.

Therefore, we urge the IUPAC and the chemical profession to reconsider the case of element 41 in favor of columbium, the name long accepted by the only industry that uses the metal commercially.



Lionel Corp.

Cadmium plate *is smooth on high and low density iron powder parts, slightly rough on impregnated parts.*

Selecting Electroplates for Iron Powder Parts

by W. H. Safranek, *Battelle Memorial Institute,*
and M. W. Wirth, *Detroit Arsenal*

Little information has been published on the plating of metal powder parts. This article, based on a comprehensive investigation, gives specific recommendations on bath formulations and detailed data on:

- *Appearance*
- *Thickness and uniformity*
- *Salt spray resistance*
- *Humidity resistance*

■ In many applications powder parts are capable of functioning in the as-sintered condition. However, where improved appearance or corrosion and wear resistance is required, some form of electroplate often becomes necessary. To determine the performance of various electroplates on iron powder parts, a comprehensive investigation has been conducted by Battelle Memorial Institute for

the Detroit Arsenal. Among the most important conclusions:

1. High density and resin-impregnated parts have better corrosion resistance after plating than low density parts.
2. Copper in resin-impregnated parts reduces corrosion resistance.
3. An acid copper sulfate bath produces better copper deposits than a copper cyanide solution.
4. Nickel sulfamate and zinc sulfate baths produce the best nickel and zinc plates.

Plating baths

The principal factors that influence the corrosion resistance of electroplated powder parts are density and copper content of the part, and throwing and covering power of the plating bath. How various plating baths compare is discussed below for each common type of electroplate. Detailed formulations and operating conditions for recommended baths are given in an accompanying table.

Cadmium plates—To determine the best method of cadmium plating iron powder parts, a thorough evaluation has been made of three plating baths—a fluoborate solution, a nonproprietary cyanide solution and a proprietary salt solution. Because of poor plate adherence, cadmium plating of parts in a fluoborate solution is not recommended. Also, in evaluating the plate deposited in a nonproprietary cyanide solution (prepared with 30 gm/l of cadmium oxide and 109 gm/l of sodium cyanide) it has been found that this bath does not throw completely into the bores of test pieces. This poor throwing power appears to occur regardless of modifications in current density or in free cyanide and addition-agent concentrations.

Of the cadmium plating baths evaluated, the best seems to be a proprietary solution of Cadalyte salts and sodium cyanide (see table). This bath produces a smooth and uniform cadmium plate with good corrosion resistance. Using a ¼-in. dia auxiliary

RECOMMENDED PLATING BATHS FOR IRON POWDER PARTS[a,b]

Bath Formulation		Operating Conditions	
CADMIUM			
Cadalyte salts	90 gm/l	Temperature	95 F
Sodium cyanide	60 gm/l	Current density	30 amp/sq ft
Cadmium metal	16.9 gm/l	Agitation	20 cpm, 2½-in. stroke
Total sodium cyanide	127.5 gm/l	Anodes	SAE 1010
Sodium hydroxide	11.25 gm/l	Anode voltage	2.1 v
		Time to deposit 0.5 mil	17 min
ZINC			
Zinc sulfate—$ZnSO_4 \cdot 7H_2O$	240 gm/l	Temperature	85F
Ammonium chloride—NH_4Cl	15 gm/l	Current density	175 amp/sq ft for 30 sec
Aluminum sulfate—$Al_2(SO_4)_3 \cdot 18H_2O$	30 gm/l		35 amp/sq ft for 30 min
Glycerine	1 gm/l	Agitation	30 cpm, 2½-in. stroke
pH	3.5	Anodes	High purity zinc
		Voltage:	
		Cathode to internal anodes	0.6 v
		Cathode to external anodes	2.0 v
		Time to deposit 0.5 mil	30 min
NICKEL			
Watts-Type Nickel Sulfate:		Temperature	110 F
Nickel sulfate—$NiSO_4 \cdot 7H_2O$	240 gm/l	Current density	45 amp/sq ft
Nickel chloride—$NiCl_2 \cdot 6H_2O$	45 gm/l	Agitation	30 cpm, 2½-in. stroke
Boric acid	30 gm/l	Anodes:	
Wetting agent solution	1.0 % by vol	External	Bagged, cast nickel ovals
pH	4.8	Internal	¼-in. dia nickel rods
		Anode voltage	1.6 v
		Time to deposit 0.5 mil	20 min
Nickel Sulfamate:		Temperature	120 F
Nickel sulfamate—$Ni(H_2NSO_3)_2$	450 gm/l	Current density	30 amp/sq ft
Boric acid	30 gm/l	Agitation	40 cpm, 2-in. stroke
Antipitting agent	0.375 gm/l	Anodes:	
pH	4.0	External	Bagged, cast nickel ovals
		Internal	¼-in. dia nickel rods
		Anode voltage	2.3
		Time to deposit 0.5 mil	30 min
CHROMIUM			
Chromic acid	248 gm/l	Temperature	120 F
Sulfuric acid	2.48 gm/l	Current density	400 amp/sq ft
		Anodes	Lead-antimony alloy
COPPER[c]			
Copper sulfate:[d]			
Copper sulfate—$CuSO_4 \cdot 5H_2O$	200 gm/l	Temperature	95F
Sulfuric acid	50 gm/l	Current density	30 amp/sq ft
Phenolsulfonic acid (65%)	1 gm/l	Agitation	Air
		Anodes	Cast copper ovals
		Time to deposit 0.5 mil	20 min
Copper Cyanide:[e]			
Copper cyanide	75 gm/l	Temperature	180 F
Potassium cyanide	125 gm/l	Current density	30 amp/sq ft
Free potassium cyanide	15 gm/l	Agitation	20 cpm, 2-in. stroke
Potassium hydroxide	35 gm/l	Anodes	Cast copper ovals
Sodium sulfocyanide	15 gm/l	Time to deposit 0.5 mil	17.5 min
Wetting agent	2.25 gm/l		

[a] Parts used in this evaluation consisted of 1 in. long cylinders with 1 in. o.d. and ½ in i.d.

[b] In a number of tests conducted with all of the recommended electrolplates, no flaking, blistering or other evidence of faulty adherence was found on any part.

[c] After copper plating, parts are rinsed in water for 30 sec, soaked in a 50-gm/l citric acid solution at 80 F for 1 min, water rinsed, and then electrolyzed cathodically for 1 min in a 2-gm/l chromic acid solution at 80 F.

[d] Prior to plating, parts are plated with nickel for 8 min at 30 amp/sq ft in the Watts-type bath described previously to prevent immersion copper deposits.

[e] Prior to plating, parts are plated at 30 amp/sq ft for 2 min in a 120 F copper cyanide strike solution consisting of 15 gm/l copper cyanide, 25 gm/l sodium cyanide and 15 gm/l sodium carbonate.

TABLE 1—APPEARANCE OF IRON POWDER PARTS AFTER PLATING

Electroplate	High Density Parts[a]	Low Density Parts[a]	Resin-Impregnated Parts[a]
Cadmium	Smooth	Smooth	Slight roughness due to roughness of parts before plating
Zinc	Smooth, except for a few shallow, small pits	Smooth, except for many relatively deep, very small pits	Smooth on copper-free parts; uneven on copper-bearing parts
Copper			
Copper Sulfate	Smooth	Smooth	Slightly rough due to uneven plate thickness
Copper Cyanide	Slightly rough because of very small nodules	Smooth, except for microscopic pits	Smooth, except for very small pits
Nickel			
Watts-Type	Smooth, but many parts badly pitted	Smooth, except for microscopic pits	Smooth, except for very small pits on some parts
Nickel Sulfamate	Smooth, except for very small pits	Smooth	Smooth, except for shallow microscopic pits on some parts
Chromium	Smooth and semibright	Smooth and semibright	Smooth and semibright

[a] Copper-free and copper-bearing parts.

anode centered inside the bore of cylindrical test pieces, equal plate thicknesses on inner and outer surfaces can be obtained. Without the internal anode, ratio of plate thicknesses on outer and inner surfaces is about 4:1.

Zinc plates—In general, zinc plating is much faster in a zinc sulfate solution than in a cyanide solution. In cyanide baths tested, zinc could not be deposited on inner surfaces, and only very thin plates were deposited on outer surfaces during 30 min of plating at a current density of 20 or 150 amp/sq ft. An acid bath containing zinc sulfate, ammonium chloride, sodium acetate and glucose produces uneven plates. Uniform, smooth deposits can be obtained, however, on high (about .25 lb/cu in.) and low (about .21 lb/cu in.) density parts using a bath made up of zinc sulfate, ammonium chloride, ammonium sulfate and glycerine (see table). To promote a smooth plate on resin-impregnated parts, an initial current density of about 175 amp/sq ft should be used.

Nickel plates—A uniform and smooth nickel plate can be obtained on low density and impregnated parts in both a Watts-type nickel sulfate and a nickel sulfamate solution (see table). Pitting, however, does appear on high density parts plated in a Watts-type bath even when a wetting agent is used. This pitting is evidently caused by hydrogen bubbles and cannot be eliminated by raising or lowering current density or by increasing agitation. In contrast, plates deposited on high density powder parts in the sulfamate bath appear satisfactory and show no traces of pitting. Apparently the sulfamate solution deposits nickel with better efficiency and with less hydrogen gassing.

Copper plates—Plating of iron powder parts in both a copper sulfate and a copper cyanide bath (see table) produces smooth copper deposits with uniform appear-

TABLE 2—APPEARANCE OF PLATED IRON POWDER PARTS AFTER STORAGE[a]

Electroplate	High Density Parts[b]	Low Density Parts		Resin-Impregnated Parts[b]
		Copper-Free	Copper-Bearing	
Cadmium	No change	No change	Many small black spots	No change
Zinc	No change	No change	Few, very small black spots	No change
Copper				
Copper Sulfate	No change	Blue-black spotting in bore	Powdery rust in bore	No change
Copper Cyanide	No change	Tarnishing of entire surface	Tarnishing of entire surface	No change
Nickel				
Watts-Type	No change	No change	No change	No change
Nickel Sulfamate	No change	No change	No change	No change
Chromium	No change	No change	No change	No change

[a] Copper- and cadmium-plated parts stored for two months; other parts stored for one month in tightly covered, tin coated steel cans containing calcium sulfate as a desiccant.
[b] Copper-free and copper-bearing parts.

Recommended Cleaning Procedure

The authors used the following cleaning procedure on 1-in. long cylindrical parts with 1 in. o.d. and a ½ in. i.d. Procedure for parts of more complex shape would probably not differ significantly from those presented here.

1. Rack each part with copper alloy spring wires contacting three points in the bore.
2. Soak 2 min at 200 to 210 F in a solution containing 8 oz per gal of a proprietary cleaner formulated for steel.
3. Anodic-clean 1 min at a current density of 75 amp per sq ft.
4. Soak in water at 160 F, then spray rinse with hot water.
5. Immerse ½-1 min in a 10% (by weight) hydrochloric acid solution.
6. Soak 1 min in water at 80 F, then spray with tap water.
7. Most parts are now ready for plating. However, for parts to be plated in cyanide bath, soak 1 min in a solution containing 15 gm per l of sodium cyanide, soak in water, then spray rinse.

ance. On hollow, cylindrical parts the ratio of plate thickness on outer and inner surfaces is about 2:1 in each bath without auxiliary anodes. The effectiveness of these baths in plating low density parts is illustrated by the accompanying photomicrographs.

Chromium plates—A uniform and smooth chromium plate on powder parts is obtainable using the formulation given in the table. The figure of 400 amp per sq ft for current density is especially important, since densities of 200, 300 and 500 amp per sq ft have been shown to produce unsatisfactory thickness uniformity. Using 400 amp per sq ft, a relatively uniform thickness is obtainable on the outer surfaces of high density and impregnated parts. To improve the uniformity of the plate on low density parts, an auxiliary external anode consisting of a wide lead band surrounding the part may be required.

Appearance of plated parts

Using the plating baths and operating conditions recommended above, a relatively smooth plate can be obtained on most low and high density powder parts. However, as indicated in Table 1, plates on resin-impregnated parts have a tendency to be uneven or pitted.

Discoloration has been observed after storage of copper-bearing, low density powder parts plated with cadmium, zinc or copper (Table 2). Low density parts plated in a copper cyanide solution tend to acquire a dark tarnish after only a few days of storage. Similar parts plated in a copper sulfate bath were discolored on inside surfaces only. No discoloration has been observed on chromium or nickel plated low density parts or on high density impregnated parts plated with cadmium, zinc or copper.

Thickness and throwing power

As shown in Table 3, minimum plate thicknesses of about 0.5 and 0.4 mil on outside and inside surfaces, respectively, can be obtained on hollow cylindrical parts, using the recommended baths. It is significant that for the same plating period only 0.5 to 0.6 mil

TABLE 3—THICKNESS OF TYPICAL ELECTROPLATES[a]

Electroplate	Type of Bath	Part Density, lb/cu in.	Copper Content of Part, %	Thickness Range, mil		Thickness Ratio on Outer Surface (Max to min)
				Outside	Inside	
Cadmium	Cadmium cyanide	0.20–0.22	5	0.5–0.7	0.4–0.7	1.40
		Impregnated	0	0.5–0.7	0.4–0.7	1.40
		0.24–0.26	5	0.6–0.9	0.55–0.85	1.50
Zinc	Zinc sulfate	0.20–0.22	10	0.5–0.90	0.4–0.6	1.80
		Impregnated	10	0.5–0.90	0.45–0.6	1.80
		0.24–0.26	5	0.55–0.90	0.45–0.6	1.64
Nickel	Watts-type	0.20–0.22	0	0.5–0.6	0.4–0.6	1.20
		Impregnated	10	0.5–0.6	0.4–0.6	1.20
		0.24–0.26	0	0.9–1.2	0.6–0.9	1.34
	Sulfamate	0.20–0.22	5	0.6–0.9	0.45–6.6	1.50
		Impregnated	5	0.6–1.2	0.6–0.9	2.00
		0.24–0.26	5	1.0–1.5	0.8–1.2	1.50
Copper	Copper sulfate	0.20–0.22	0	0.9–1.2	0.4–0.6	1.34
		Impregnated	5	0.6–0.9	0.25–0.6	1.50
		0.24–0.26	0	0.9–1.1	0.4–0.6	1.22
	Copper cyanide	0.20–0.22	0	0.6–1.2	0.4–0.8	2.0
		Impregnated	0	0.6–0.9	0.4–0.8	1.5
		0.24–0.26	5	0.6–1.2	0.4–0.8	2.0
Chromium	Chromic acid	0.20–0.22	0	0.7–1.5	0.45–1.2	2.22
		Impregnated	0	0.7–1.2	0.35–0.6	1.67
		0.24–0.26	5	0.7–1.2	0.5–1.2	1.71

[a] 1 in. long specimen with 1 in. o.d. and ½ in. i.d.

TABLE 4—RESISTANCE OF ELECTROPLATED PARTS TO SALT SPRAY FOG[a]

Electroplate	Copper Content of Part, %	High Density Parts		Low Density Parts		Impregnated Parts	
		First Appearance of Rust, hr	10–15% Rusted, hr	First Appearance of Rust, hr	10–15% Rusted, hr	First Appearance of Rust, hr	10–15% Rusted, hr
Cadmium	0	259	1285	10	212	248	1584
	5	335	1434	10	292	276	1040
	10	328	1360	10	14	294	840
Zinc	0	415	567	340	562	316	416
	5	312	435	159	272	295	366
	10	292	340	13	31	301	367
Nickel							
Watts-Type	0	12	134	12	131	15	205
	5	3	28	9	95	15	216
	10	6	101	3	17	12	89
Nickel Sulfamate	0	9	196	15	248	15	322
	5	15	278	23	240	15	297
	10	15	228	12	171	15	278
Copper							
Copper Cyanide	0	5	191	5	78	7	294
	5	5	153	5	15	5	160
	10	6	147	5	12	5	142
Copper Sulfate	0	10	307	24	379	5	208
	5	10	268	24	277	5	142
	10	10	336	20	323	5	165
Chromium	0	24	90	24	101	22	129
	5	22	94	24	96	12	71
	10	22	114	23	71	14	71

[a] Tests conducted in accordance with Federal Specification QQ-M-151, paragraph 41.

of nickel plate were deposited on low density parts compared to 0.9 to 1.5 mil on high density parts.

Judged by the small range of plate thickness on outer surfaces, the Watts-type nickel bath and the cadmium cyanide and copper sulfate baths all exhibit good throwing power. By comparison, throwing power of the chromium plating solution is slightly inferior.

All of the electroplates listed in Table 3 appear to have good microthrowing power on high density parts. (Microthrowing power is usually defined as the efficiency with which an electroplate fills the pores adjacent to the surface.) With the exceptions of cadmium and chromium, all of the baths also appear to possess good microthrowing power on low density parts. Chromium deposits have a tendency to bridge over surface pores instead of filling them. All baths listed, with the exceptions of zinc and copper sulfate, are capable of providing a uniform plate on resin-impregnated surfaces.

Salt spray resistance

Relative salt spray resistance of the various electroplates on iron powder parts is indicated by the values in Table 4. In general, high and low density and impregnated parts plated with nickel, chromium or copper (sulfate bath) are about equal in salt spray resistance. The more protective zinc or cadmium electroplates are slightly more resistant on high density parts than on resin-impregnated parts. Low density parts with zinc, cadmium or copper (copper cyanide bath) electroplates tend to rust sooner than high density parts similarly plated. The figures for cadmium, in particular, indicate that the sacrificial action of cadmium is not sufficient to compensate for discontinuities in the plate.

In general, plated iron powder parts that are copper-free are more resistant to salt spray corrosion than copper-bearing parts. This is especially true of zinc plated parts. The adverse influence of copper content is much greater in low density and impregnated powder parts than it is in high density parts. Low density parts containing 10% copper exhibit very poor corrosion resistance.

Humidity resistance

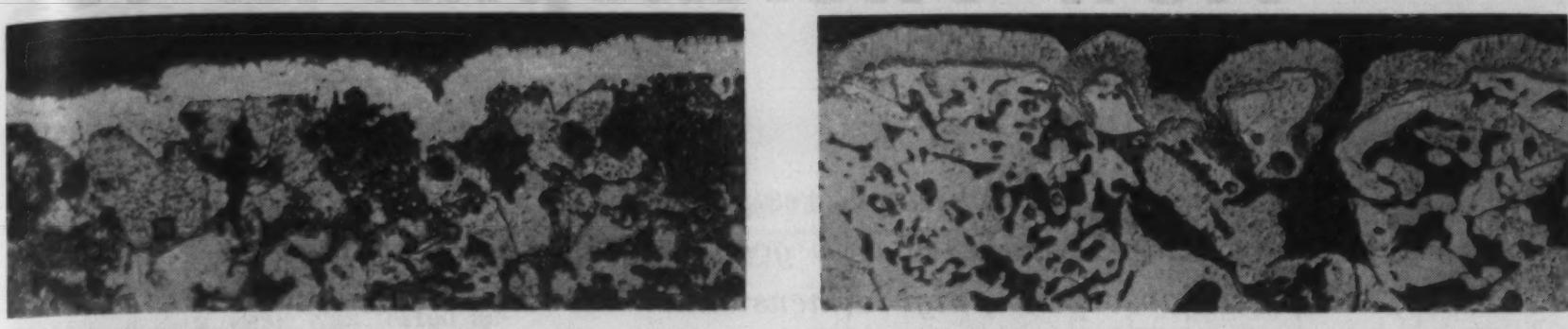
As indicated in Table 5, parts

TABLE 5—APPEARANCE OF PLATED FERROUS POWDER PARTS AFTER HUMIDITY TEST[a]

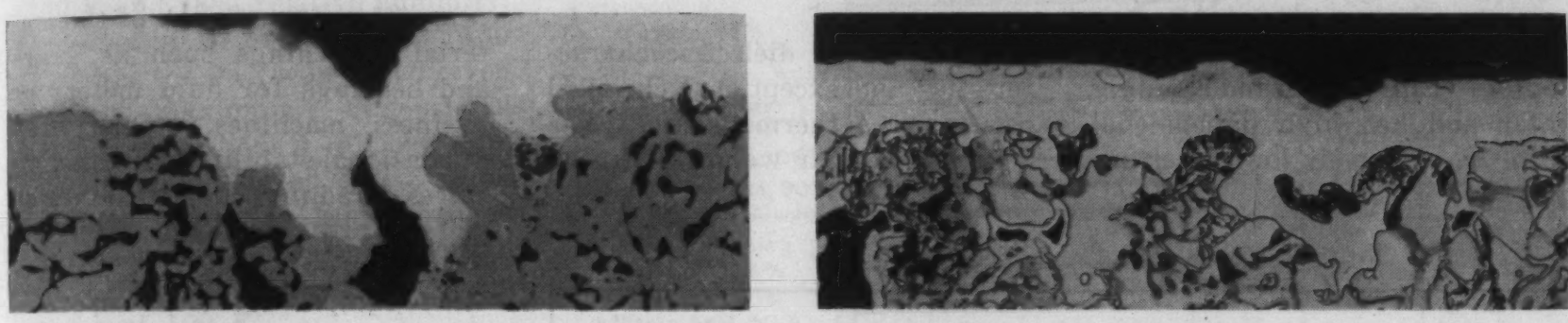
Test Period, hr	Low Density Parts		High Density and Impregnated Parts	
	Copper-Free	Copper-Bearing	Copper-Free	Copper-Bearing
CADMIUM PLATE				
24	No corrosion products	Large black spots	No corrosion products	No corrosion products
72–408	No corrosion products	Tenacious black film mixed with white corrosion products	No corrosion products	No corrosion products
1042	Entire surface darkened by small black spots	Few pinpoints of rust, plus black and white corrosion products	Entire surface darkened by small black spots	Entire surface darkened by small black spots
ZINC PLATE				
24–408	White corrosion products	White corrosion products	White corrosion products	White corrosion products
1042	Some rusting	White corrosion products	White corrosion products	White corrosion products
COPPER PLATE				
24	Few pinpoints of rust products from pores	Few pinpoints of rust products from pores	Few pinpoints of rust products from pores	Few pinpoints of rust products from pores
72	Same as above	Darkening of surface with 25–30 pinpoints of rust	Surfaces covered with rust products; all rust could be washed away	Some parts covered with rust products; rust could be washed away
240–408	Same as above	Entire surface covered with tenacious black film	Same as above	Same as above
1042	Same as above plus partial covering of one specimen with tenacious black film	1–2% rusting and tenacious black film	High density parts covered by tenacious black film; no change in impregnated parts	Same as above plus darkening of some surfaces
NICKEL PLATE (Nickel sulfamate bath)				
24	25–30 pinpoints of rust	25–30 pinpoints of rust	25–30 pinpoints of rust	25–30 pinpoints of rust
72	More than 30 pinpoints of rust; all rust could be washed away	More than 30 pinpoints of rust; all rust could be washed away	More than 30 pinpoints of rust[b]; all rust could be washed away	More than 30 pinpoints of rust; all rust could be washed away
240–1042	Same as above	Same as above	Same as above	Same as above
CHROMIUM PLATE				
24	25–35 pinpoints of rust	25–35 pinpoints of rust	25–35 pinpoints of rust	25–35 pinpoints of rust
72–1042	Many pinpoints of tenacious rust products	Many pinpoints of tenacious rust products	Many pinpoints of tenacious rust products	Many pinpoints of tenacious rust products

[a] Military Specification JAN-H-792. Humidity cabinet maintained at 130 F; air flow at 8 linear ft per hr.
[b] High density, copper-free parts exhibited at least twice as much rust as impregnated parts.

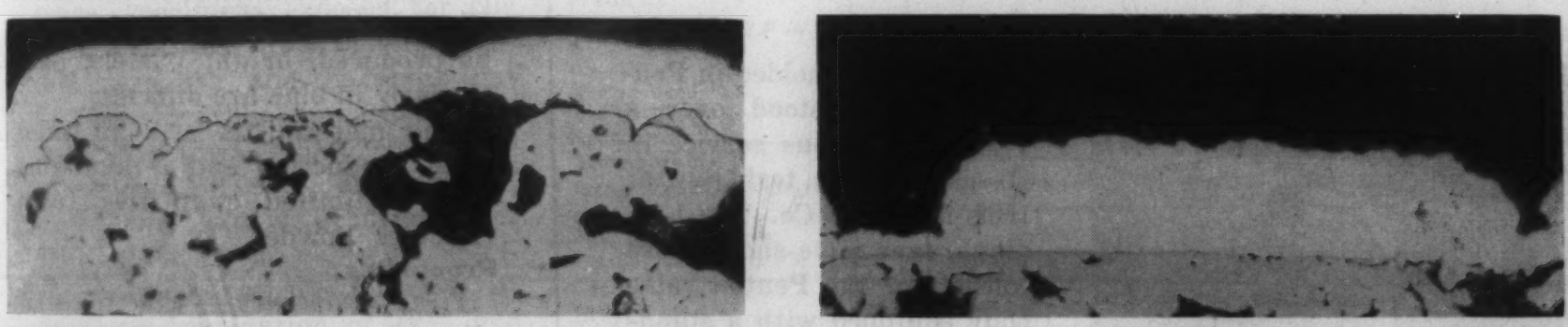
How Electroplates Compare



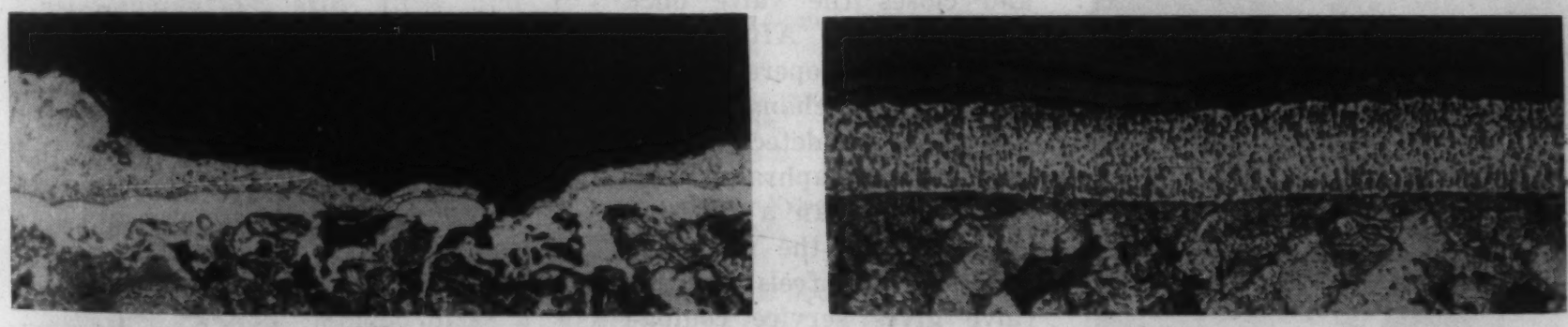
Copper plates *from either a copper sulfate (left) or a copper cyanide (right) bath are smooth and have uniform appearance on* low-density *iron powder parts.*



Zinc and nickel plates *indicate baths possess good microthrowing power on* low-density *parts. Zinc plate (left) was deposited from zinc sulfate bath; nickel plate (right) was obtained in Watts-type bath.*



Cadmium plate *(left), in common with nickel, chromium and copper (cyanide bath) plates, is uniform on* resin-impregnated *parts. Plates deposited from zinc (right) and copper sulfate baths are generally inferior.*



Copper plates *deposited on* resin-impregnated *parts. Plate produced in sulfate bath (left) is markedly inferior to plate obtained in copper bath (right).*

plated in a nickel sulfamate bath exhibit less corrosion during humidity tests than any other plated parts. Corrosion products consisting of small pinpoints of rust have been noted on nickel plated parts after only 24 hr of testing, but these rust spots did not increase appreciably after 1042 hr and could be easily washed off.

Most copper and chromium plated parts also show evidence of rusting after 24 hr. However, after continued exposure these parts acquire a tenacious black film. In general, rusting is greater on copper-bearing, low density parts.

Zinc plated parts exhibit a considerable amount of white corrosion products after only 24 hr of humidity testing. By comparison, the performance of cadmium plated parts is much better, except for copper-bearing, low density parts which acquire large black spots after 24 hr, a mixture of black and white spots after 72 hr, and rust spots after 1042 hr of testing.

New Thermoplastic for

Chlorinated polyether resin has chemical resistance akin to that of the fluorocarbons combined with good heat resistance, low water absorption, high dimensional stability and good dielectric qualities.

■ The chlorinated polyether resin, Penton, can withstand boiling water and has high dimensional stability, extremely low water absorption, stable dielectric characteristics and exceptional chemical resistance. A thermoplastic, it has a high molecular weight, is linear and crystalline in nature and is highly resistant to thermal degradation at molding and extrusion temperatures. The resin can be injection molded or extruded on conventional equipment.

This interesting combination of properties suggests use of the material for things such as gears and bearings for fluid meters or business machines, where high dimensional stability is necessary; valves handling chemicals, water and low pressure steam; electrical insulation or valves for refrigeration equipment; and impermeable films.

Unpigmented, Penton is a straw-colored semitranslucent material. Though most colors and white can be produced, bright pastels, particularly in blue are difficult.

The material is still in pilot plant production and is available only in limited quantities from Hercules Powder Co.

Properties

Heat resistance — The material's resistance to elevated temperatures is better than that of most thermoplastics. ASTM heat distortion temperature under 264 psi stress is 185 F. However, at 212 F the material retains a tensile strength of 3500 psi, or slightly over 50% of original. Heat distortion temperature under 66 psi stress is 300 F. Dimensional stability at elevated temperatures is further illustrated by the fact that an injection molded 3-in. dia gear changes only 1 mil in dimension as a result of 20 min exposure to 300 F. Thus, products made of the material will maintain stability at sterilizing temperatures, and the resin can be used in hot water equipment, such as valves, which has been beyond the working capacity of conventional thermoplastic resins.

Water absorption—Penton has an extremely low water absorption

Here's One Application . . .

Hills-McCanna Co.

Molded valve body

Valve body molded in Penton has withstood over a year's continuous service in 60 psig steam test line at Hills-McCanna Co. The 1-in. diaphragm valve shown here consists of the Penton valve body equipped with a standard cast iron top works and a control device which opens and closes the valve once every 3 min. After more than a year of operation less than 0.001 in. change in any dimension was detected. Also, the Teflon diaphragm has caused less than a 1/32-in. impression in the material. Hills-McCanna feels that the valve gives service comparable to a cast iron valve under the same service conditions.

Hills-McCanna has also tested 2-in. flange valves lined with Penton in the same type of steam service. Results of tests on the lined valves are identical with those on the molded valve body.

Tough Service Conditions

value—on the order of 0.01%—which results in a high degree of dimensional stability. For example, a 2-in. disk was tested according to ASTM D756-46T (1), which involves 25 hr exposure at 140 F and 88% relative humidity, followed by 24 hr dry heat at 140 F. After the disk was cycled seven times, maximum dimensional change was about 1 mil per 2 in. An injection molded disk 2 in. in diameter and ⅛ in. thick, changed less than 1 mil in any dimension when exposed for 195 days in water at 100 F.

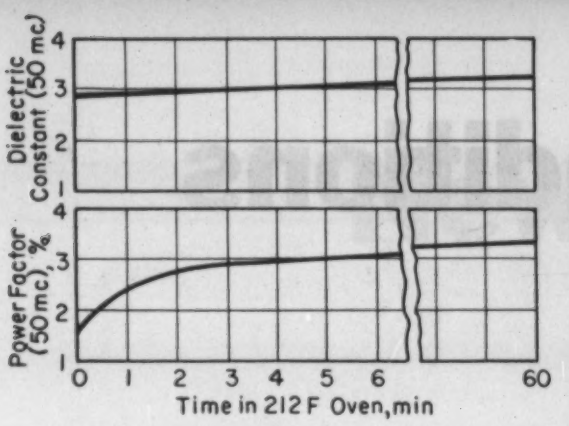
Weather resistance — During outdoor weathering tests in Delaware, specimens exposed for one year retained their original tensile strength and hardness but lost considerable elongation. Original specimens had a tensile strength of 6000 psi, elongation of 80% and Rockwell hardness of R97. After 6 mo exposure, specimens had a tensile strength of 6500 psi, elongation of 12% and hardness of R103. After 1 yr exposure, tensile strength was 6100 psi, elongation still 12% and hardness R97. Preliminary data indicate that some chalking occurs on exposure in Florida.

Electrical properties—Retention of the electrical properties shown in the accompanying table is good even after exposure to adverse conditions such as water and temperature change. Molded disks 2 in. in dia and ⅛ in. thick have a dielectric constant (50 mc) of 3 and a power factor of 0.02. After 1 wk immersion in water at 77 F, neither of these values is changed. After 1 wk immersion in water at 212 F, dielectric constant is still 3 and power factor has altered slightly to 0.03. An accompanying graph shows the effect of 212 F dry heat on dielectric constant and power factor. There is no sharp change in dielectric constant as the pieces start to heat up, and when they reach a temperature of 212 F throughout, change in dielectric constant is quite small.

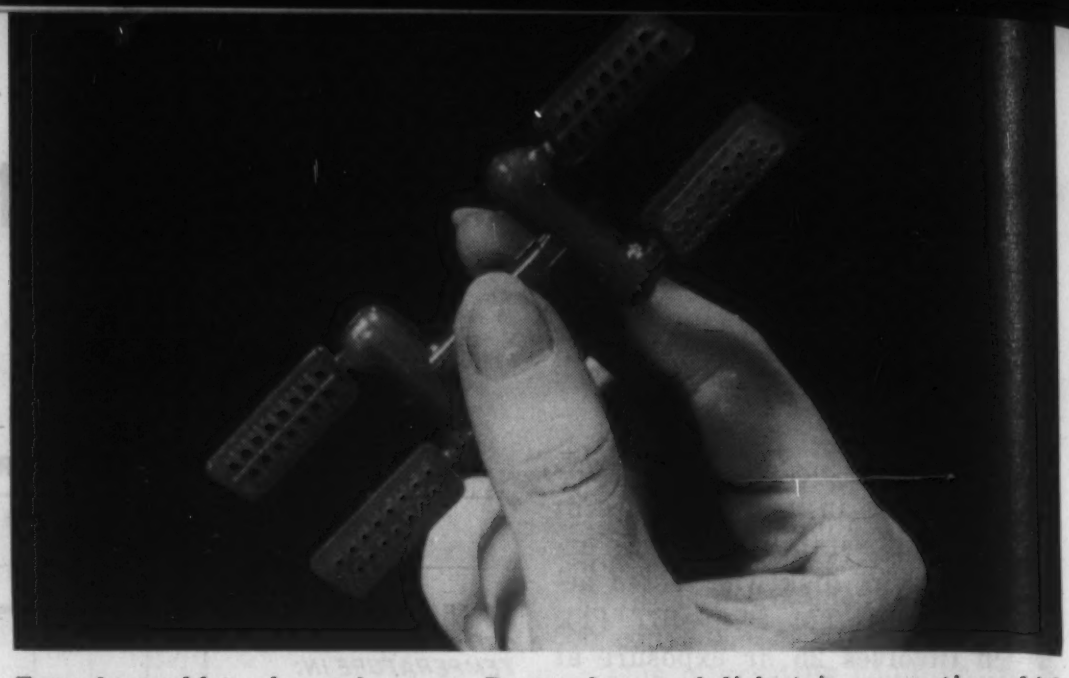
EFFECTS OF VARIOUS REAGENTS IN NEW RESIN

Reagents	Tensile Strength, psi (0 1000 2000 3000 4000 5000 6000 7000 8000)	Change in Wt., %	Appearance
CONTROL, NO EXPOSURE			
ONE WEEK AT ROOM TEMPERATURE IN:			
Acetophenone		+0.0	No change
Chromic Acid, 33% + Sulfuric Acid, 3%		+0.0	No change
Ethyl Ether		+0.6	No change
Ethylene Dichloride		+1.1	No change
Furan		+0.8	No change
Hydrofluoric Acid, 100%		+1.05	No change
Hydrogen Peroxide, 90%		+0.1	No change
Lemon Oil, 5% in Alcohol		+0.3	No change
Nitric Acid, Fuming	*Failed*	—	Fragmented
Sulfuric Acid, 96%		+0.6	No change
Sulfuric Acid, 50% + Nitric Acid, 50%		+0.1	No change
ONE WEEK AT 150 F IN:			
Freon 12		+1.1	No change
Freon 22		+3.6	No change
ONE WEEK AT 212 F IN:			
Air		−0.3	No change
Acetic Acid, 15% + Formic Acid, 5%		−0.3	Brown
Acetone		+4.3	Slight distortion
Acetophenone		+25.9	Distorted
Ammonium Hydroxide, 10%		0.0	Light brown
Caprylic Acid		+0.8	Brown
Chromic Acid, 33% + Sulfuric Acid, 3%		−0.6	No change
Coconut Oil		−0.1	No change
Ethyl Acetate		+5.3	Distorted
Ethyl Alcohol, 95%		+1.2	No change
Ethylene Dichloride	*Failed*		
Furan		+7.4	Slight distortion
Hydrochloric Acid, 37%		+0.2	Dark brown
Lemon Oil, 5% in Alcohol		+1.8	Slightly bleached
Nitric Acid, 10%		+0.4	Slightly bleached
Phenol, 90%		+5.7	Orange
Sodium Hydroxide, 15%		−0.4	Brown
Sulfuric Acid, 30%		−0.2	Dark brown
Sulfuric Acid, 96%		−3.2	Black
Toluene		+8.1	Slight distortion
Toxaphene, 90% in Xylene		+2.5	Brown
Triton X770, 0.05%		−0.3	Brown
Water, Distilled		+0.3	Light brown
THREE MONTHS AT ROOM TEMPERATURE IN:			
Acetone		+5.2	Slight distortion
Ammonium Hydroxide, 10%		+0.1	No change
Aniline, 10%		+0.03	No change
Ethyl Acetate		+3.6	No change
Ethyl Ether		+0.6	No change
Ethylene Dichloride		+6.0	Slight distortion
Furan		+6.5	Slight distortion
Heptane		+0.1	No change
Hydrochloric Acid, 37%		+0.1	No change
Toluene		+1.5	No change
Water, Distilled		+0.05	No change

Chemical resistance—The table of chemical resistance shows relatively little change in tensile



Effect of temperature *on power factor and dielectric constant. Test parts were at room temperature (77 F) before being placed in oven. They reached oven temperature (212 F) after 1 hr.*



Easy to mold *to close tolerances, Penton has good dielectric properties which make it useful for parts such as these electrical connectors molded by aaRBee Plastic Co.*

strength, weight or appearance as result of immersion in chemicals.

Design and fabrication

Since Penton can be fabricated by injection molding or extrusion with standard equipment, intricacy of design can range from flat and cylindrical parts to intricate pump parts and valves. Design limitations are generally the same as those for any injection molding. During molding, material temperature from the cylinder may range between 370 and 465 F. For optimum cycle time, die temperatures should be maintained between 190 and 205 F; higher or lower die temperatures result in longer cycles. The 190-205 F die temperature ensures production of stress-free moldings.

Cycle time is dependent on wall thickness. Sections up to 1/16 in. can be molded in 20 sec or less; from 1/16 to ⅛ in., up to 30 sec; from ⅛ to ¼ in., up to 45 sec; and from ¼ to ½ in., up to 80 sec. Selection of proper gate size is extremely important to gain rapid cycles. Melt viscosity of Penton is quite low, permitting thin sections to be filled out rapidly during injection.

Extrusions have been made without difficulty in 0.005 to 0.030-in. thick sheet, 0.010 to ⅜-in. dia rod, and 1/16 to ¾-in. i.d. pipe or tubing. Barrel and die temperatures may range from 360 to 450 F, depending on the item. For example, 0.005-in. thick sheet requires temperatures of about 430 F, whereas pipe of heavier cross section requires temperatures of only 360 to 400 F.

MECHANICAL PROPERTIES OF PENTON

Specific Gravity		1.4
Spec Vol, cu in. lb		19.8
Mold Shrinkage, in./in.		0.004–0.006
Tensile Strength, psi:	D638-52T	
73 F		6000
212 F		3500
Tensile Modulus, psi:	D638-52T	
73 F		160,000
212 F		90,000
Elongation, %:	D638-52T	
73 F		60–160
212 F		200–250
Flexural Strength (beam, 73F), psi	D790-49T	5000
Flexural Modulus (73 F), psi	D790-49T	127,000
Water Absorption, %	D570-42	0.2
Izod Impact, ft lb/in. notch:	D256-47T	
Notched, 73 F		0.4
Unnotched, 73 F		33
Notched, —4 F		0.2–0.3
Unnotched, — 4 F		1.5
Notched, — 40 F		0.2–0.3
Unnotched, — 40 F		1.5
Rockwell Hardness (73 F)	D785-48T	R100
Deformation under load (122 F, 2000 psi), %	—	1.4
Comp Str (1% offset), psi	D695-52T	8800
Compressive Modulus, psi	D695-44T	130,000
Heat Distortion (5 x ½ x ½-in. bar), F:	D648-45T	
264 psi		185
66 psi		300
Flammability (⅛ x ½ x 6-in. bar)	D635-44	Self-extinguishing
Therm Coeff of Linear Exp, per F	D696-44	About 0.64×10^{-4}
Molding Temp, F	—	440–465
Injection Molding Pressure, psi	—	10,000–20,000

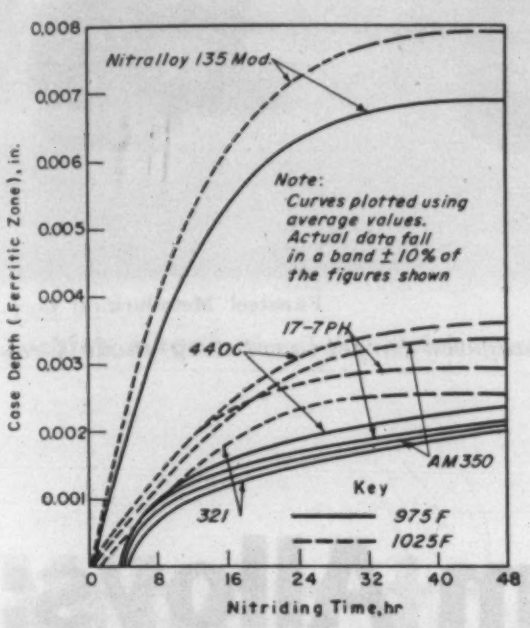
ELECTRICAL PROPERTIES OF PENTON[a]

Loss Factor:	D150-47T	
50 cps to 1.2×10^6 cps		0.03
1.23×10^6 cps		0.04
67×10^6 cps		0.06
Dissipation Factor:	D150-47T	
50 cps to 1.23×10^6 cps		0.01
67×10^6 cps		0.02
Dielect Const (50 cps to 67×10^6 cps)	D150-47T	3
Vol Resist, ohm-cm	D257-49T	1×10^{15}
Dielect Str, v/mil	D149-44	400
Dielect Str, v/2-mil film	—	4000

[a] Injection molded disks ⅛ in. thick.

Nitriding Stainless Steels Costs Less in a Salt Bath

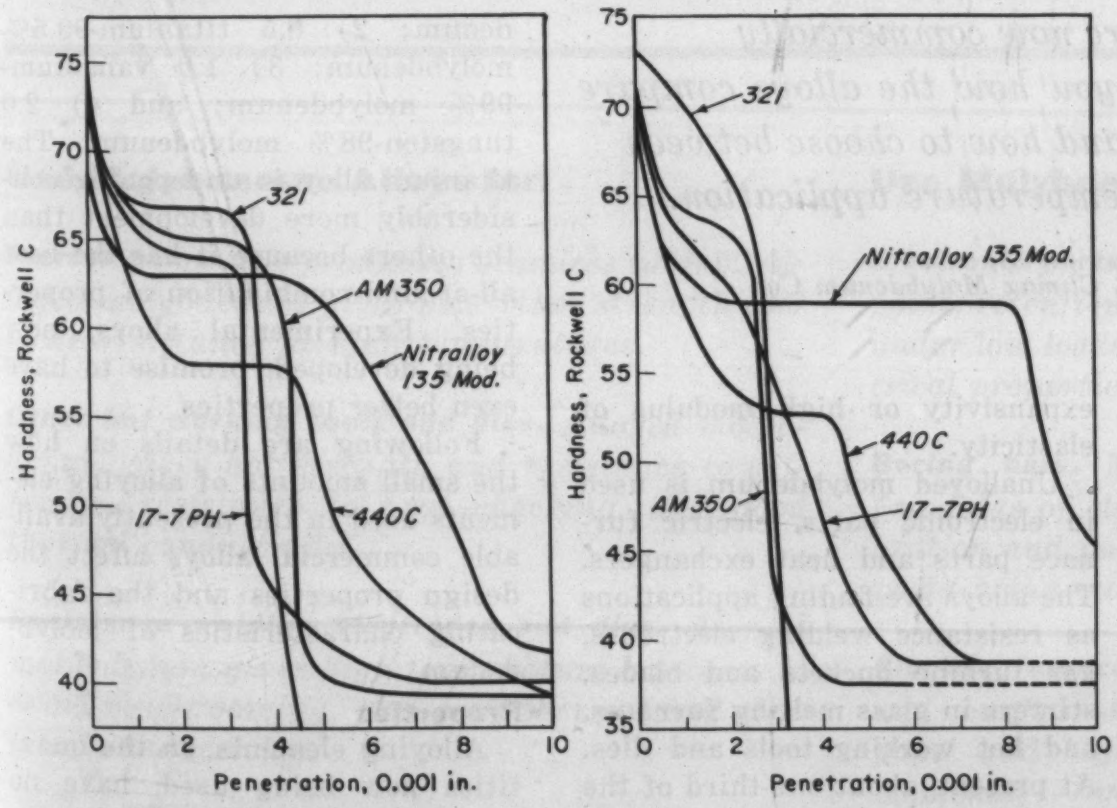
by H. A. Johnson,
Boeing Airplane Co.



***Typical case depths** after nitriding at 975 F and at 1025 F.*

HEAT TREATMENTS BEFORE NITRIDING

Material	Treatment
Nitralloy 135, Mod.	1725, oil quench; 1500 F, 2 hr
AISI 440 C	1875 F, oil quench
17–7 PH	1400 F, 1½ hr; 1050 F, 1½ hr
AM 350	1700 F, water quench; −100 F, 2 hr; 850 F, 2 hr
AISI 321	Annealed



***Typical hardness gradients** after nitriding at 975 F (left) and 1025 F. Surface hardness measured with Vicker's Hardness Tester using 1-kg load. Remaining measurements with Tukon tester using Knoop indenter and 250-gm load.*

■ Stainless steel can be nitrided in a salt bath at lower cost than in the conventional gas nitriding furnace. Although the case is only half as thick as that produced by gas nitriding in equivalent time, the surface reaches a hardness of Vickers 1355 and is resistant to oxidation up to 600 F.

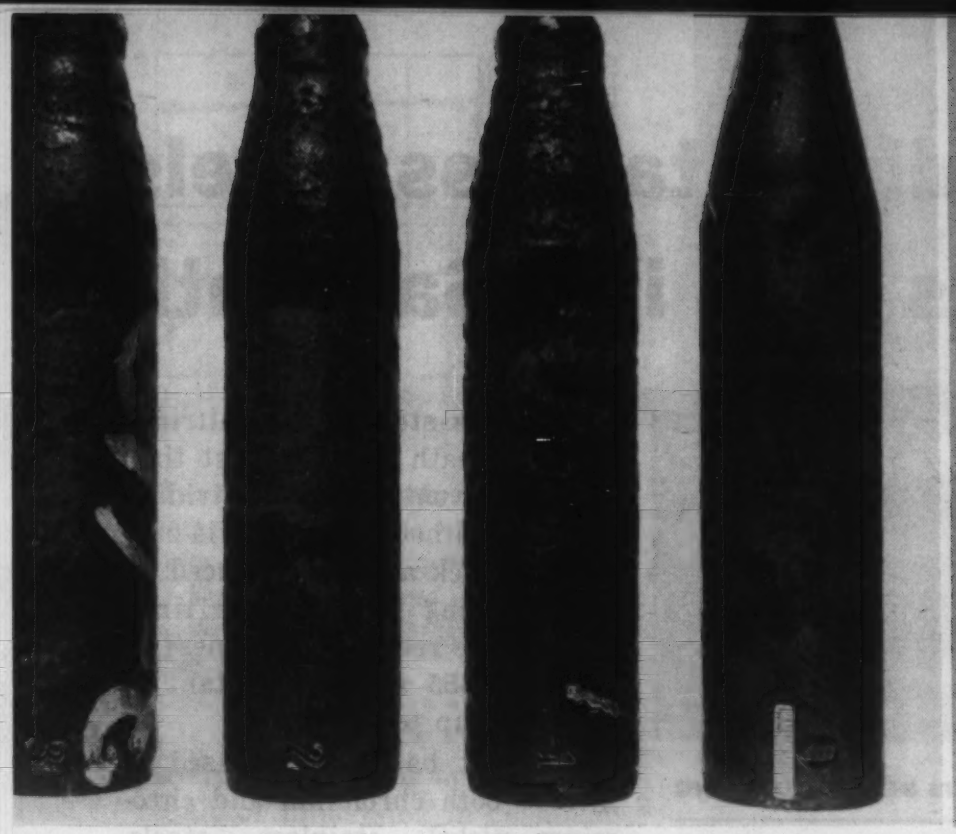
The salt bath can be used to nitride both chromium and chromium-nickel stainless steels. Among the stainless steels successfully treated by this method are AISI 321 and 440C, AM 350 and 17-7 PH. The heat resisting chromium-nickel alloy A-286 has also been salt bath nitrided.

Parts are nitrided at 975 to 1050 F, case depth depending on treatment time. Typical values are given in the accompanying graphs. For comparison, results obtained on Nitralloy 135, Modified, are included. The heat treatments used before nitriding are listed separately.

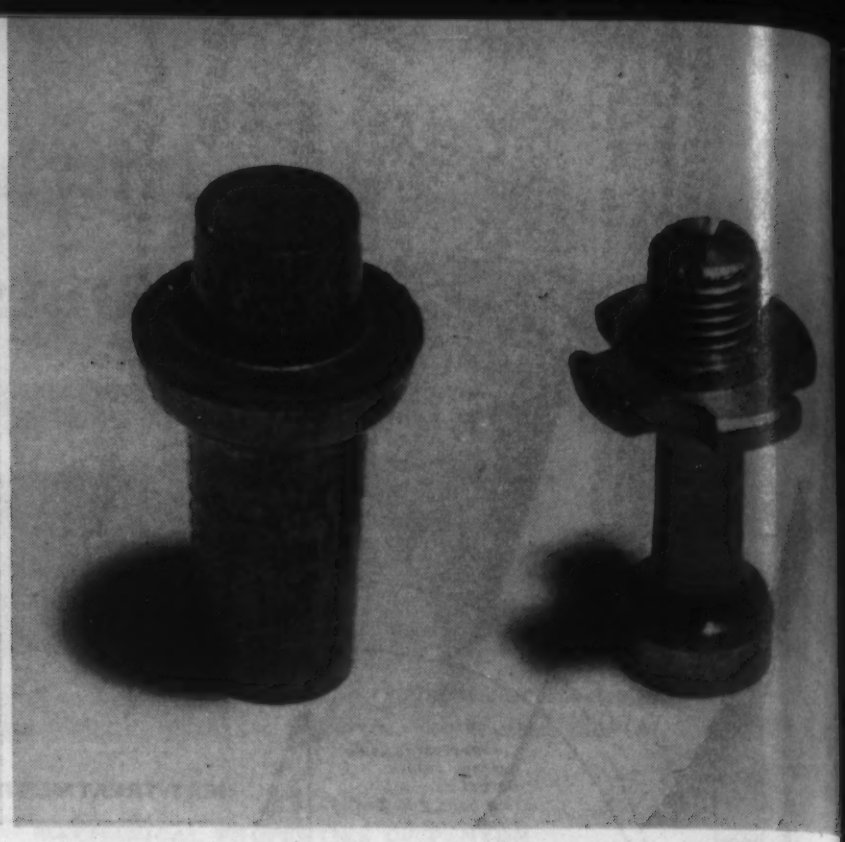
Case depths obtained on the various stainless steels in a given time period are quite similar. For example, after 24 hr at 975 F, the depths range from 0.0015 in. for AISI 321 to 0.0019 in. for AISI 440C. In contrast, under the same conditions case depth on Nitralloy 135, Modified, is 0.0062 in.

The liquid salt nitriding procedure developed for hardening high speed steels is used in nitriding stainless steels. A proprietary salt composed of a mixture of carbonates and cyanides serves as the nitriding medium. Only degreasing and buffing are required to prepare the steel surfaces for nitriding. However, an adherent nickel coating 0.001 in. thick is needed to mask areas where nitriding is not desired.

Nitriding is performed by suspending the materials in the unagitated bath. After nitriding, the parts are air quenched and rinsed in water to remove the salt.



Piercer points *of molybdenum alloy. Point at right is unused. Other points shown have pierced from 74 to 110 billets of Type 304 stainless steel.*



Fansteel Metallurgical Corp.

Support *for tungsten target in rotating-anode X-ray tube.*

Molybdenum Alloys:

Several molybdenum alloys are now commercially available. This article tells you how the alloys compare with unalloyed molybdenum and how to choose between them for a particular high temperature application.

by R. R. Freeman and J. Z. Briggs, *Climax Molybdenum Co.*

■ With the recent introduction of molybdenum alloys to the field of high temperature materials, the design engineer contemplating the use of molybdenum must decide between the unalloyed metals and one of the alloys now available. The alloys are superior to unalloyed molybdenum in applications where high temperature hardness and strength or resistance to softening by recrystallization is required. On the other hand, there is no reason to consider alloyed molybdenum for applications that depend solely on the physical properties of molybdenum—its high melting point, high thermal and electrical conductivity, low expansivity or high modulus of elasticity.

Unalloyed molybdenum is used in electronic parts, electric furnace parts and heat exchangers. The alloys are finding applications as resistance welding electrodes, gas turbine buckets and blades, stirrers in glass melting furnaces, and hot working tools and dies. At present, about one-third of the arc-cast molybdenum is alloyed, and the proportion should increase as the properties of molybdenum alloys become more widely known.

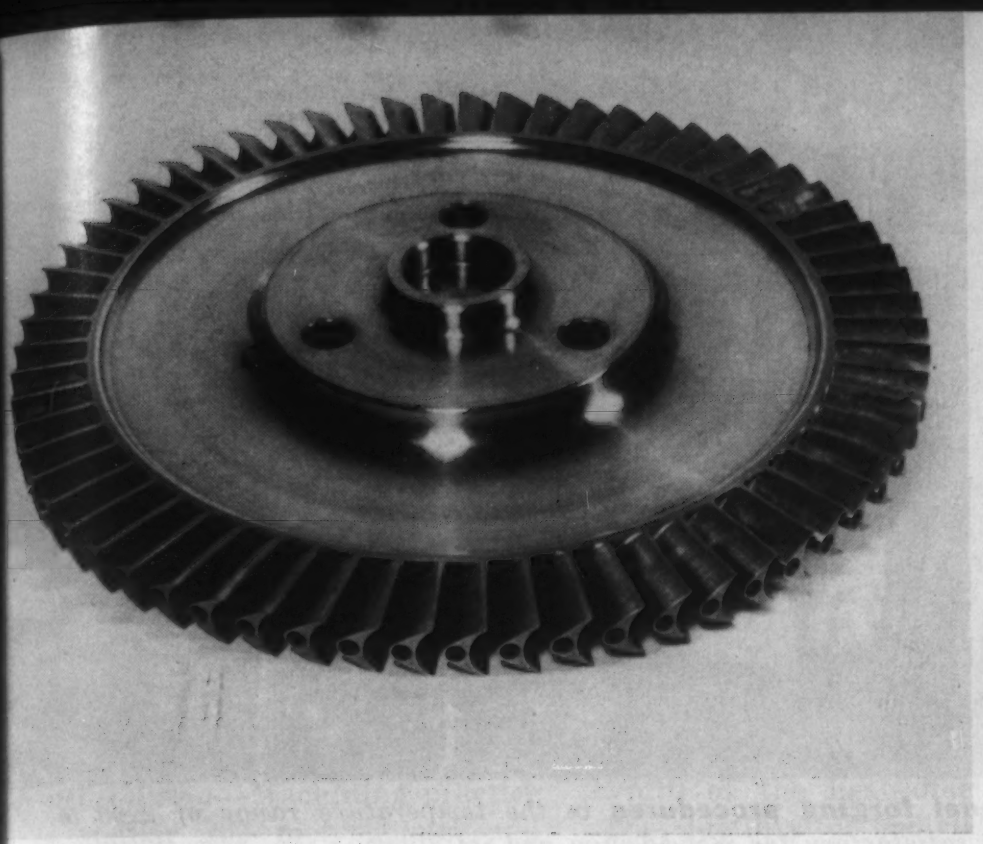
Four arc-cast molybdenum alloys are in commercial production: 1) 0.3 columbium-99.7% molybdenum; 2) 0.5 titanium-99.5% molybdenum; 3) 1.0 vanadium-99% molybdenum; and 4) 2.0 tungsten-98% molybdenum. The titanium alloy is undergoing considerably more development than the others because it has the best all-around combination of properties. Experimental alloys, now being developed, promise to have even better properties.

Following are details on how the small amounts of alloying elements used in the presently available commercial alloys affect the design properties and the fabricating characteristics of molybdenum.

Properties

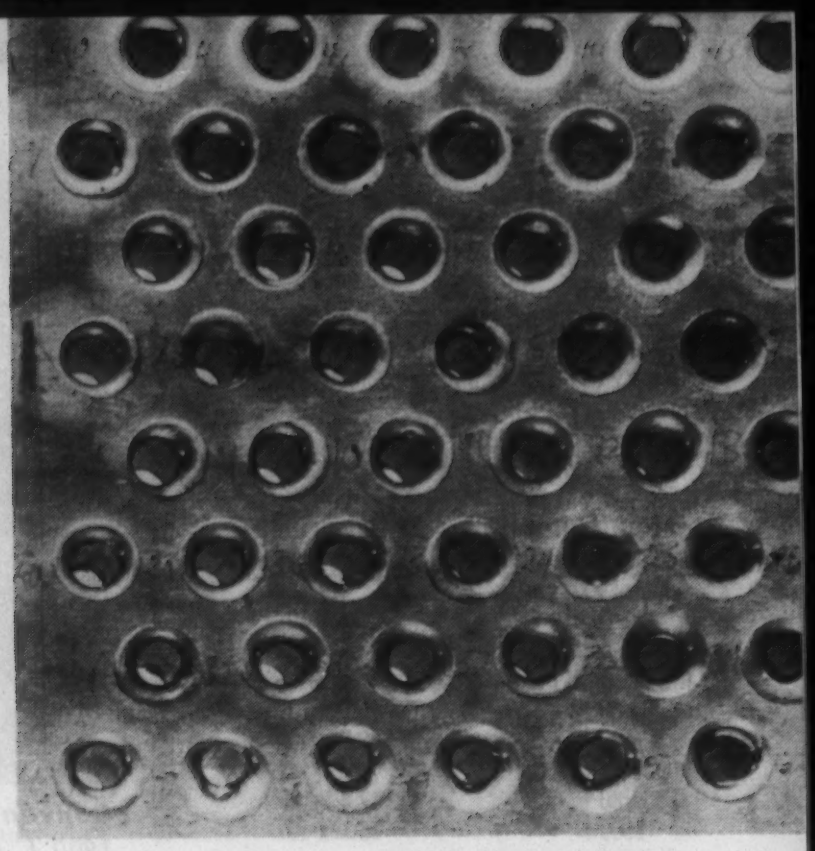
Alloying elements, in the quantities now being used, have no significant effect on physical properties. The values given in Table 1 can be used for both molybdenum and the four commercial alloys.

On the other hand, alloying improves mechanical properties, especially high temperature strength



Experiment Incorporated

***Turbine wheel** of solid molybdenum.*



Battelle Memorial Institute

***Header** of molybdenum for experimental heat exchanger.*

When to Use Them

Use Molybdenum Alloys for:

Piercer points *for producing seamless tubing. Alloyed molybdenum gives maximum strength and wear resistance at high temperatures.*

Other hot working tools and dies. *Alloyed molybdenum gives hot strength and resistance to softening, resistance to heat checking, and good thermal conductivity.*

Resistance welding electrodes and dies. *Alloyed molybdenum gives high temperature hardness to avoid mushrooming, plus good thermal and electrical conductivity.*

Stirrers and accessories for glass melting furnaces. *Alloyed molybdenum gives high hot strength, high melting point, good electrical conductivity and resistance to attack by molten glass.*

Gas turbine buckets and guide vanes. *Alloyed molybdenum gives highest possible strength at the highest possible temperature.*

Use Molybdenum for:

Electronic parts. *Molybdenum gives high melting point, retention of stiffness at high temperatures under low loads, and favorable physical and electrical properties.*

Boring bars. *Molybdenum gives high rigidity (modulus of elasticity) needed for minimum vibration and good surface finish and accuracy of parts being machined.*

Electric furnace parts. *Radiation shields, baffles and muffles—molybdenum gives high melting point and high thermal conductivity. Heating elements — molybdenum gives good electrical properties and high melting point.*

Truing resinoid-bonded diamond wheels. *Molybdenum gives good frictional characteristics.*

Heat exchangers. *Molybdenum gives low expansivity, high thermal conductivity, and resistance to liquid metals such as sodium and lithium.*

TABLE 1—PHYSICAL PROPERTIES OF MOLYBDENUM[a]

Atomic No.	42
Atomic Wt	95.95
Crystal Structure	Body centered cubic
Melting Pt, F	4730
Density (68 F), lb/cu in.	0.369
Elec Cond (32 F), % IACS	34
Spec Ht (70 F), Btu/lb/F	0.061
Therm Cond, Btu/hr/sq ft/F	
70 F	72[b]
1650 F	62
Coeff of Exp per F:	
68 to 212 F	3.16×10^{-6} [c]
68 to 1832 F	3.37×10^{-6}
Mod of Elast in Tension, psi	
80 F	46.0×10^{6}
1600 F	39.9×10^{6}
Mod of Rigid, psi	
80 F	17.4×10^{6}
1600 F	15.1×10^{6}

[a] Unalloyed molybdenum and the alloys presently available have about the same physical properties.

[b] 0.5% Ti—Molybdenum has slightly lower thermal conductivity at room temperature (68 vs 72 for unalloyed molybdenum) but the same value at about 1300 F and higher.

[c] 0.5% Ti—Molybednum shows slightly lower expansivity at ambient temperatures (e.g., at 68—212 F, 3.06 instead of 3.16) but the values became almost the same at higher temperatures (e.g., at 68—1832 F, 3.41 for the alloy vs 3.37 for the unalloyed).

and hardness. Short-time tensile strength of the alloy containing 0.5% titanium is almost as high at 1600 F as that of unalloyed molybdenum at room temperature (Table 2). This alloy also shows a marked increase in stress rupture strength (Table 3).

Alloying also increases the recrystallization temperature. After 97% reduction by hot rolling at 2200 to 1900 F, the minimum temperature for full recrystallization in 1 hr is 2150 F for unalloyed material and 2450 F for the 0.5% titanium alloy.

The importance of hardness and strength in highly stressed parts to be used at high temperatures is evident. The significance of the recrystallization temperature may not be immediately clear. Mechanical properties of unalloyed molybdenum depend to a large degree on the amount of mechanical working done below the recrystallization temperature. This is also true for present-day alloys because they are not heat-treatable and rely entirely on mechanical work for strengthening.

***Conventional forging procedures** in the temperature range of 2200 to 1900 F are satisfactory for molybdenum and its alloys.*

(Some precipitation-hardenable alloys have been investigated in the laboratory, but they cannot be processed with available facilities.) Since the effects of mechanical working are lost when a metal recrystallizes, the recrystallization temperature sets an upper limit to the operating temperatures.

At 1600 F, for example, fully recrystallized material has about 40 to 50% lower stress rupture strength (100 hr) than mechanically worked and stress relieved material of the same grade. This difference decreases as the operating temperature increases, but the mechanically worked material still has a significant edge in strength as long as recrystallization does not occur.

The 0.5%-titanium alloy has greater structural strength at temperatures over 1600 F than any other commercially known material. Design data at 2000 F are shown in an accompanying figure.

Fabrication

Forming — Mechanical working procedures for molybdenum alloys are basically the same as those for unalloyed molybdenum. For

TABLE 2—ELEVATED TEMPERATURE TENSILE PROPERTIES

Material[a]	Test Temp	Ten Spirts	0.1% Yld Str, psi	Elong, %	Red of Area, %
Unalloyed Mo	81	97,200	82,900	42[b]	69.0
	750	62,400	57,200	20	81.2
	1200	65,200	48,100	22	86,1
	1600	54,200	33,400	24	88.6
0.5 Ti, 99.5% Mo	80	132,100	99,100	31	70.0
	750	110,000	89,000	18	72.8
	1200	100,500	84,000	17	74.1
	1600	88,300	76,500	15	71.1

[a] Both materials stress relieved 1 hr at 1800 F after rolling to ⅝-in. dia.

[b] Elongation in 1 in. for 0.250-in.-dia test specimen.

TABLE 3—STRESS RUPTURE STRENGTH

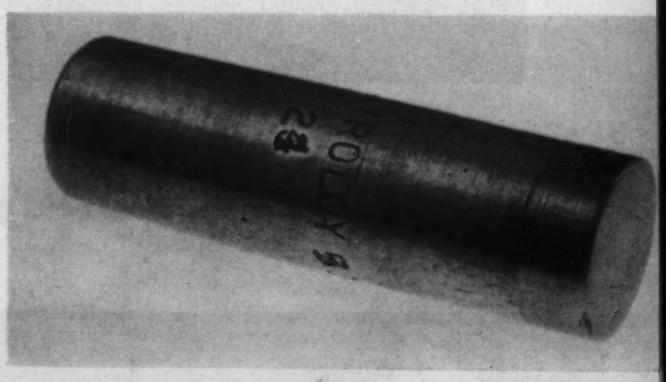
Material	Stress to Produce Rupture in 100 hr at Indicated Temp, psi					
	Stress Relieved			Recrystallized		
	1600 F	1800 F	2000 F	1600 F	1800 F	2000 F
Unalloyed Mo	31,000	22,000	13,000	16,000	11,500	9000
0.5 Ti, 99.5% Mo	66,000	53,000	34,000	34,500	28,000	21,000

optimum ductility, parts should be given at least a 50% reduction in area by mechanical working below the recrystallization temperature. Although more energy is required to deform the molybdenum alloys, the difference is seldom sufficient to be noticeable in practice. On the other hand, although unalloyed molybdenum can be forged at temperatures down to 1700 F, most of the alloys crack if forged below 1900 F. Except for extremely fine wire and sheet, at least a moderate amount of heating is recommended for all forming operations.

Machining—Machining practice is similar for molybdenum and the alloys. Either high speed steel or sintered carbide tools can be used, with tool angles and rakes about the same as those used for cast iron. Cast cobalt-base alloy tools have not proved satisfactory. A mixture of 50 chlorinated oil-50% trichloroethylene or highly chlorinated oil is recommended as a cutting fluid. A prior treatment has little effect on the machinability of molybdenum. Molybdenum is considerably more abrasive than steel at the same hardness, and the lower expansion of molybdenum makes it particularly important to keep tools sharp and cool in drilling operations.

Welding—Arc-cast molybdenum and the alloys discussed here have weldability superior to that of commercially available powder metallurgy molybdenum. Welds can be produced without porosity or cracks. Unless it is possible to work the welded joints mechanically, the welds and heat-affected zones will have lower room temperature ductility than the parent metal. At present, the most satisfactory welds in heavy sheets and parts are made by the inert-gas-shielded arc process using tungsten electrodes, with or without filler wire additions. Some organizations prefer helium to argon because of the greater heat produced at the arc and the smaller width of the heat-affected zone. The ductility of molybdenum is adversely affected by even small amounts of oxygen in the welding atmosphere. Electrolytic cleaning before welding is recommended for best results. Flash welding, resistance welding, brazing and mechanical methods of joining hold promise where they can be used.

Coating—At temperatures above 1000 F, unprotected molybdenum oxidizes so rapidly in air or oxidizing atmospheres that its continued use under these conditions is impractical. There seems to be no hope of developing alloys that will combine oxidation resistance and high strength at elevated temperatures. Much work is therefore being done to find adequate methods of surface protection. Some of these methods have proved highly successful on a laboratory scale, and a commercially feasible method of protecting molybdenum appears to be not too far away, particularly for applications where a useful life of 500 to 1000 hr is acceptable. Among the three most promising methods are cladding, electroplating and spray coating (metallizing). Although most of the investigations have been carried out on unalloyed molybdenum, the same protection methods appear to be applicable to molybdenum alloys. The only difference observed to date is in the diffusion treatment used to bond the metallized coating, where an argon atmosphere seems to be more suitable for alloyed molybdenum than the hydrogen atmosphere customarily used for unalloyed molybdenum.

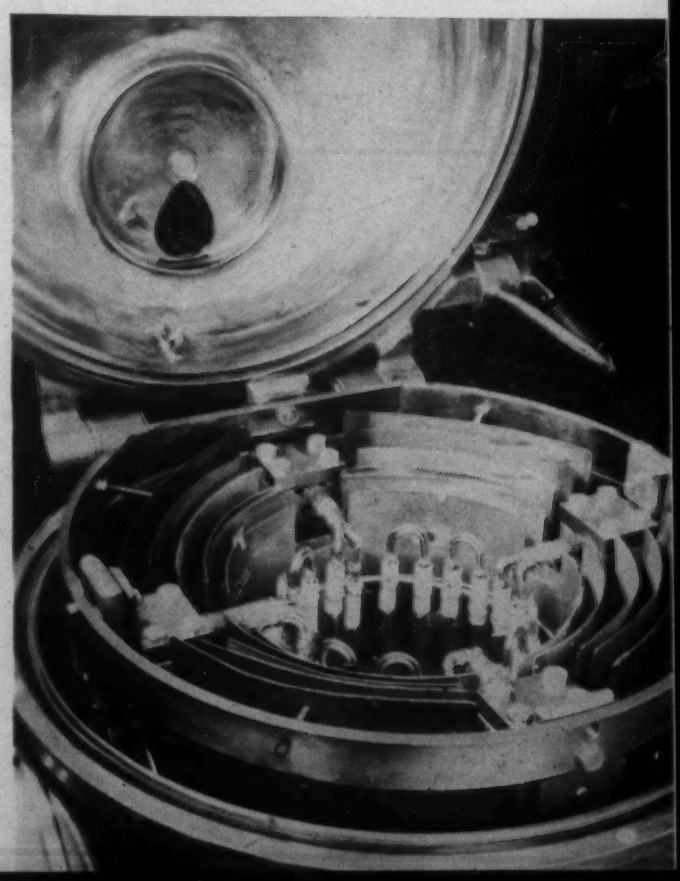


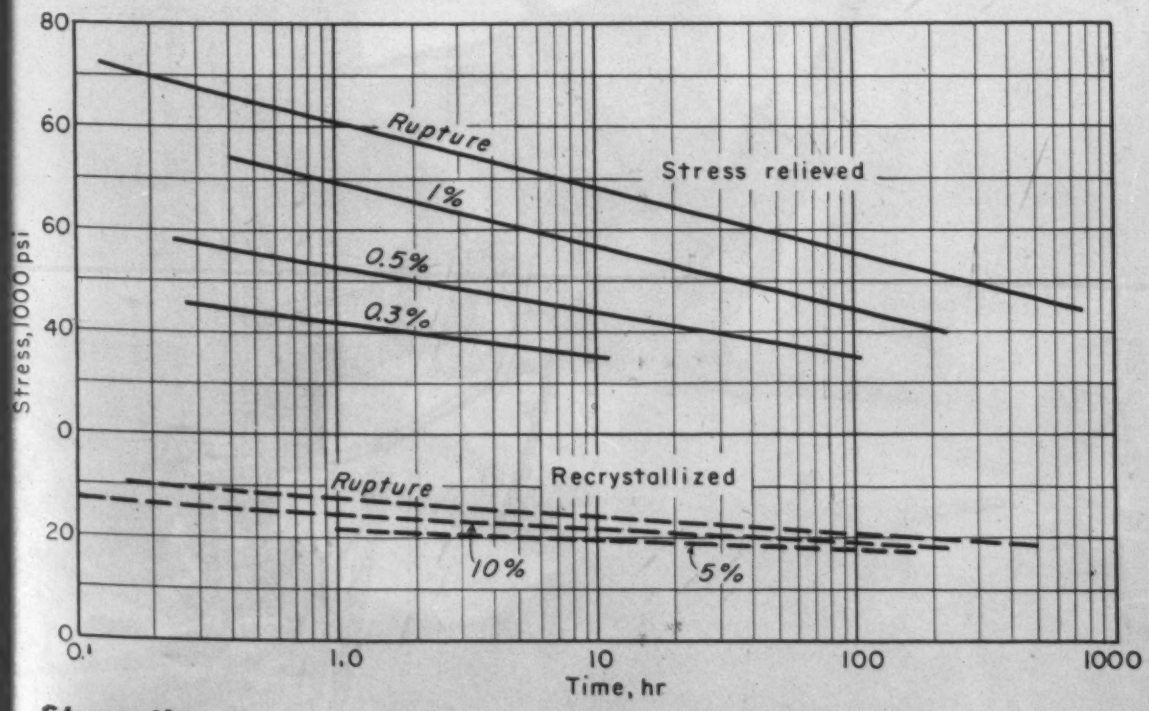
Electroloy Co., Inc.

Resistance welding electrode *faced with molybdenum.*

Heating gage *and radiation shields of molybdenum used in Balzers high vacuum sintering furnace.*

Geraetebau-Anstalt, Liechenstein





Stress-time *curves for various amounts of total deformation for 0.45% titanium alloy at 2000 F. Tested in vacuum.*

MATERIALS AT WORK

Northrop Aircraft machines fragile, tissue-thin metal honeycomb rapidly and economically by an unusual technique. Water is poured into the honeycomb blank, then frozen to stiffen the material and make it as machinable as solid metal. Without such stiffening, the material is easily crushed under the impact of the cutter.

The frozen honeycomb is cut by a circular tool which can form bevels, slots and convex or concave shapes. The size of parts is limited only by the capacity of the milling machine and the refrigeration equipment.

Iced metal honeycomb is easier to machine

Aluminum smokestacks lighten luxury liners

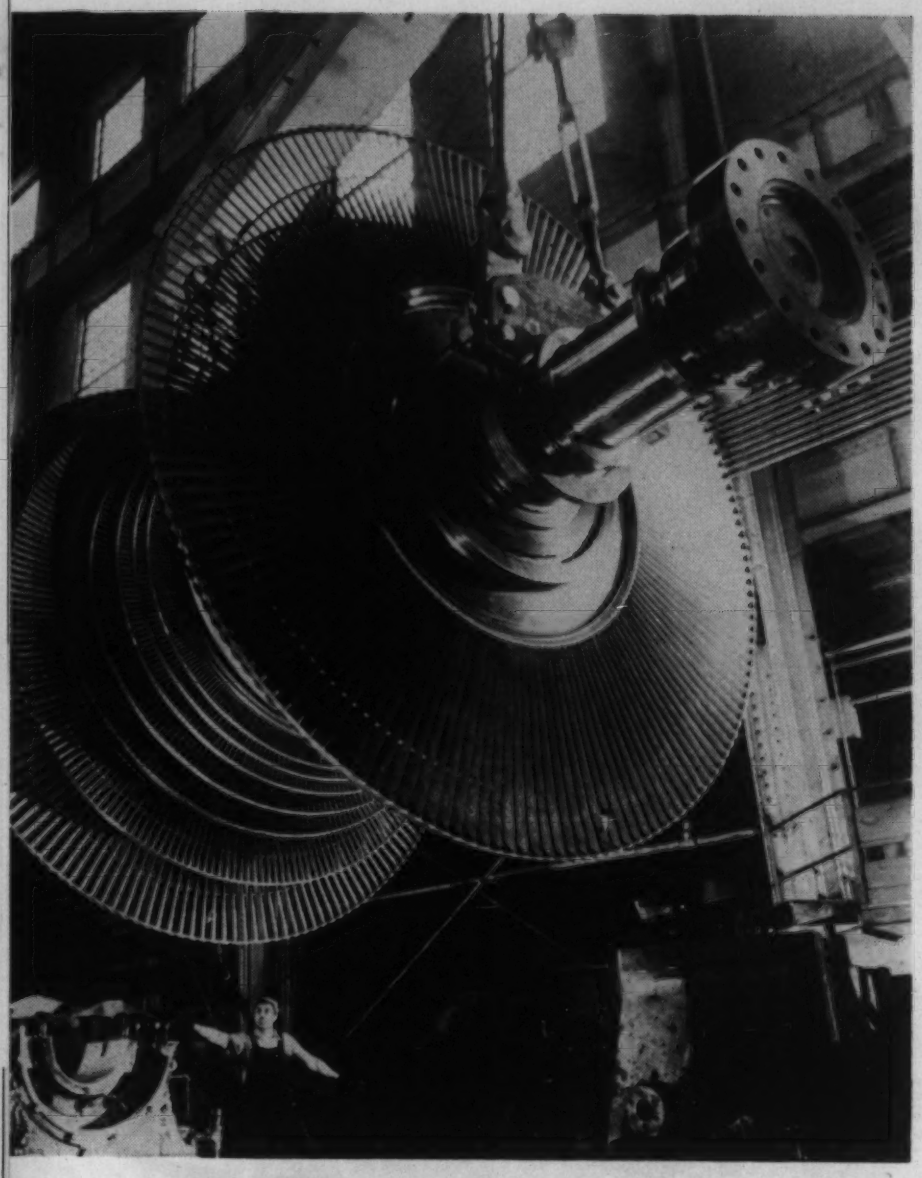
Streamlined aluminum smokestacks, containing approximately 17,000 lbs of aluminum alloy plate each, enhance the beauty and stability of Matson Navigation Co.'s two new 365-passenger ships, the "Mariposa" and the "Monterey."

Use of aluminum rather than steel saved an estimated 15 tons of superstructure weight. The reduced weight will lower the center of gravity on each vessel, thereby providing greater stability and smoother sailing.

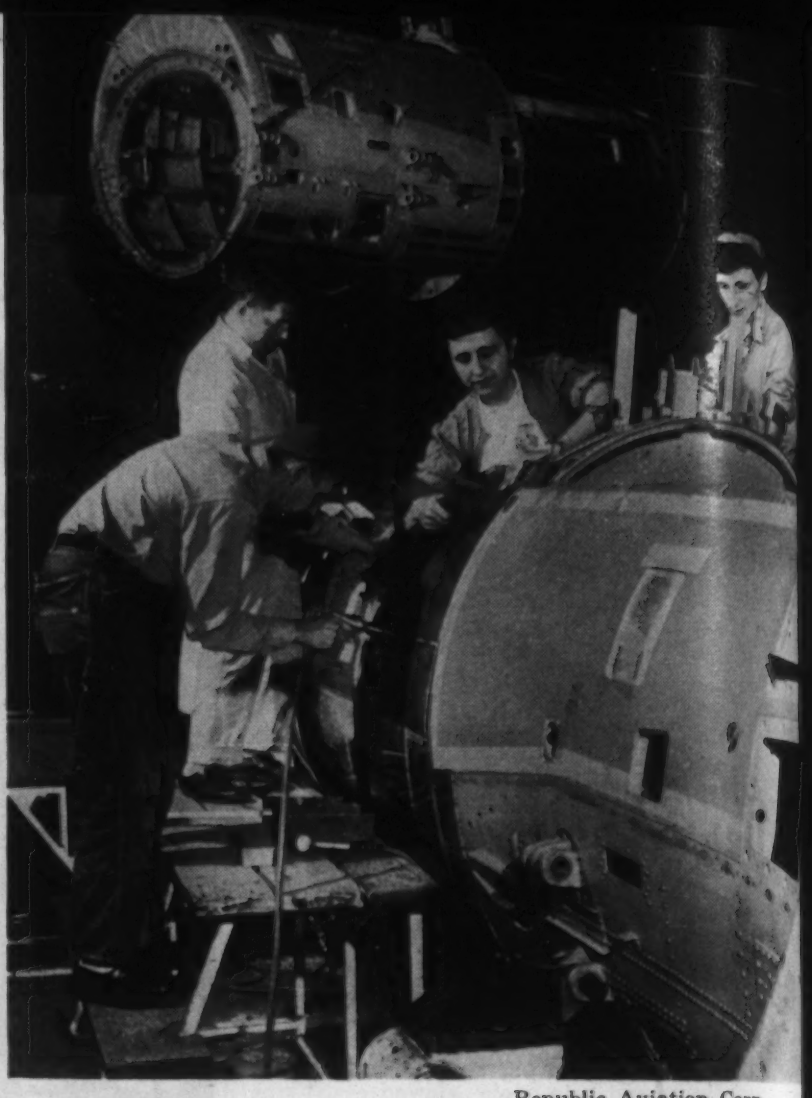
Supplied in 8 x 20 ft sections, the ¼-in. plate was cut with a small rotary saw, then formed and riveted to the 42-ft-high framework. The stacks will be painted blue and buff over a zinc chromate primer.

The aluminum plate was supplied by Kaiser Aluminum & Chemical Corp. The stacks were fabricated at the Willamette Iron & Steel Co. shipyard in Portland, Ore.

Lifting *the stack into place.*



Steam turbine rotor *must be designed on the basis of long-time creep data to insure many years of continuous operation.*



Republic Aviation Corp.

Aircraft fuselage *subject to heating is a more complex design problem, despite shorter life, since deformation is not free but restrained.*

How to Use Creep Data in Design

Proper use of creep and creep-rupture data is essential in solving many high temperature design problems. This article explains the significance of creep data and shows how they are applied to the design of both long-life and short-life equipment.

by Ward F. Simmons, *Battelle Memorial Institute*

■ Creep—the time-dependent plastic deformation of a metal under stress—can occur under tension, compression, bending, shear, bearing or combined stresses. For most engineering structural materials, however, creep is a design problem only at elevated temperatures.

Creep data have been applied to the design of equipment for long-time service for many years. However, the increased speed of aircraft, with resulting aerodynamic heating, has made creep a

problem that must also be considered in aircraft design. Many of the design problems resulting from increasing service temperatures can be solved through better use of creep and creep-rupture data.

For purposes of this discussion, the use of creep and creep-rupture data has been arbitrarily divided into three categories:

1. *Creep in stationary equipment*—Steam power, power gas turbines, etc. Long-term creep covering a period of 10 to 20 yr of continued operation.

2. *Creep in aircraft components*—Aircraft gas turbines, rocket motors, missiles, etc. Short-term creep with time periods from seconds for rockets to several thousand hours for commercial aircraft engines.

3. *Creep in airframe structures*—Small amounts of creep, usually less than 0.5% plastic deformation, and relatively short times (at present) of certainly not more than a few hundred hours.

The need for consideration of creep data in airframe design is comparatively recent and is limited to structures in which aerodynamic heating and heating caused by close proximity of jet engines can be expected. Since the problem of creep is new in airframe design, this aspect of the use of creep data is emphasized here.

Creep in stationary equipment

Materials applicable to the design of boilers, steam turbines, steam piping, oil refinery equipment and power gas turbines must receive careful consideration. Since such equipment is intended to have a service life of 10 to 20 yr or more, laboratory test data must be determined in long-time tests, although judicious extrapolation of data from shorter tests is permissible. Creep and rupture (or stress-rupture) tests of 2000 to 10,000 hr duration are commonplace, and some tests are run to longer times.

The plastic strain or creep that occurs in a test specimen or in a part in service is largely permanent strain or deformation and, once it has taken place, the life of the specimen or part has been reduced by the amount of the strain. The nature of one type of design problem can be illustrated by the following example. Suppose a turbine blade can deform 1% before it rubs on the casing, and 0.5% of this is elastic strain. Then, when the blade deforms only 0.25% in creep, it has used up three-fourths of its useful life

Developing Creep and Creep-Rupture Data

Creep or creep-rupture data are usually determined by 1) subjecting a suitable specimen to a tensile load while it is held at a constant temperature, 2) measuring the instantaneous elastic or elastic plus plastic strain, and 3) measuring the continuing extension with time. Similar measurements are made for different stresses and for different temperatures. A creep-rupture or rupture test is essentially a creep test that is continued until the specimen fails.

The strain data are usually plotted against time to give the typical time-strain curve shown in Fig 1. Segment AB of this curve is the instantaneous strain on loading, and consists of elastic or elastic-plus-plastic strain. The elastic strain is instantly recoverable when the load is removed. A portion of the inelastic strain is also recoverable over a period of time. The amount of recoverable elastic strain can be computed with some confidence, but the amount of recoverable inelastic strain is governed by laws which are at present quite obscure. Accordingly, when recoverable inelastic strain is important, it must be measured under conditions closely simulating service.

The time-dependent portion of the curve begins with segment BC—the first stage of creep—which is characterized by a decreasing creep rate. The second stage of creep, CD, is represented by a relatively constant creep rate which is also the minimum creep rate measured during the test. The third stage, DE, is characterized by a continually increasing rate of creep until failure occurs at point E.

Creep and rupture tests are normally made at constant temperature and load, using various stresses to yield a family of curves as shown in Fig 2. The second-stage or minimum creep rates from these curves and the rupture times from the higher load tests are plotted against stress as shown in Fig 3. Log-log graph paper is used because the data often plot as straight lines on this type of paper, making a reasonable extrapolation a simple matter.

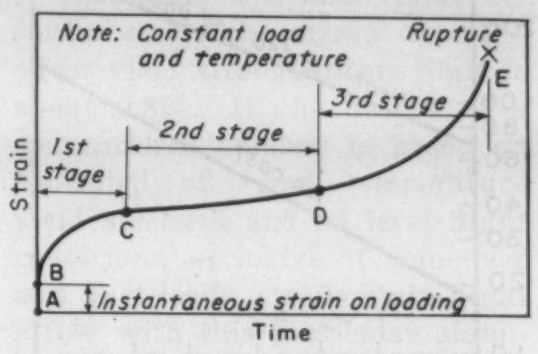


Fig 1—*Typical time-strain curve showing the three stages of creep.*

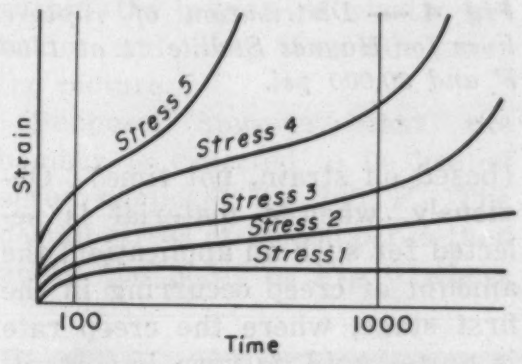


Fig 2—*Time-strain curves at constant temperature and increasing load.*

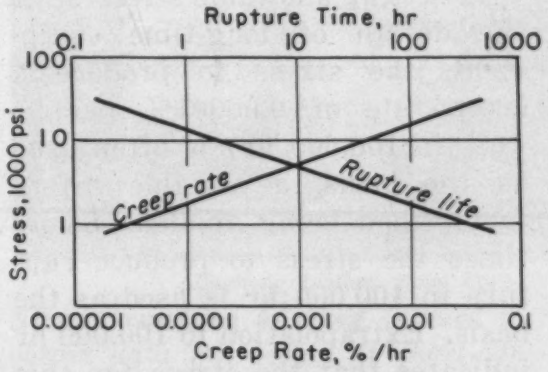


Fig 3—*Log-log plots of stress vs creep rate and rupture time.*

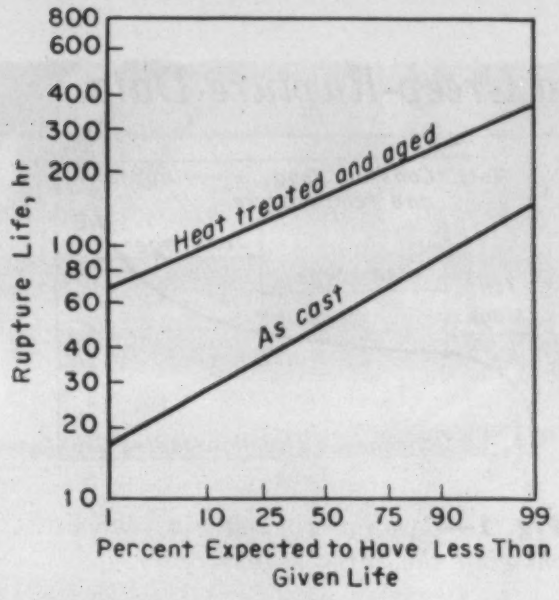


Fig 4 *— Distribution of rupture lives for Haynes Stellite 31 at 1500 F and 30,000 psi.*

(based on strain, not time). Obviously, when a material is selected for such an application, the amount of creep occurring in the first stage, where the creep rate is quite rapid, is very important. Other things being equal, a material exhibiting a small amount of first stage creep would be selected.

In setting allowable stresses for the design of long-time equipment, the stress to produce a creep rate of 0.00001% per hr (1% in 100,000 hr) is often used as the basis, a suitable safety factor then being applied. Sometimes the stress to produce rupture in 100,000 hr is used as the basis. Extrapolation to 100,000 hr indicates that the stress for this rupture time is frequently, though not always, about double the stress required to produce a creep of 1% in the same period of time (0.00001% per hr). No matter what basis is used in arriving at the allowable stresses for long-time design, a reasonable safety factor can be used. This fortunate circumstance does not apply to the design of aircraft components where every extra pound is multiplied manyfold in decreased payload carrying capacity.

Creep in aircraft components

With the development of the aircraft engine turbosupercharger and the gas turbine jet aircraft engine, the use of metals at high temperatures for short times, usually less than 1000 hr, became a critical problem. In contrast to long-time design, where the emphasis is on creep rates for determining allowable stresses, jet engine materials are evaluated and selected on the basis of rupture strength (the stress to produce rupture in a given time, such as 100 or 1000 hr).

The designer of aircraft components is highly weight conscious. Parts must be as light as possible, but must not fail in service. This is not too difficult to accomplish, without overdesign, if the parts made from one alloy all have the same strength. Unfortunately, variations in the strength properties of an alloy can be quite large. In effect, the wide range of properties forces the designer to base his design on the minimum properties determined in the laboratory.

Fig 4 indicates the scatter of rupture test results that can be expected in a cast cobalt-base alloy (approximately 27 Cr, 10 Ni, 7.5% W, bal. Co) in both the as-cast and heat treated conditions. For example, suppose 100 specimens of the as-cast alloy were tested at 1500 F and 30,000 psi. One specimen would be expected to rupture in 17 hr, 50 specimens in 50 hr, and all but one specimen would have failed by 150 hr. Heat treating the alloy by heating at 2225 F and aging at 1300 F for 16 hr increases the strength considerably and decreases the scatter slightly, as indicated by the lesser slope of the curve. These data make it easy to understand why, even with all of the engineering know-how that has accumulated during the last decade, the final answer to the adequacy of materials and design is still given by engine tests.

Most components no longer fulfill their original function after they have deformed by an amount fixed by the design. Thus, since the amount of deformation at rupture is variable, creep-rupture data must always be used with a safety factor. Recently, a more precise criterion than rupture strength has frequently been used

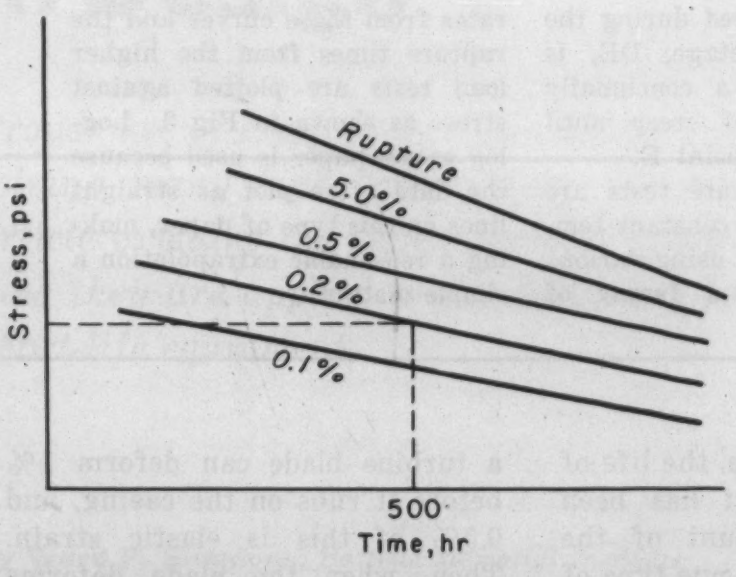


Fig 5*—Design curves relating time and stress for various amounts of strain at constant temperature.*

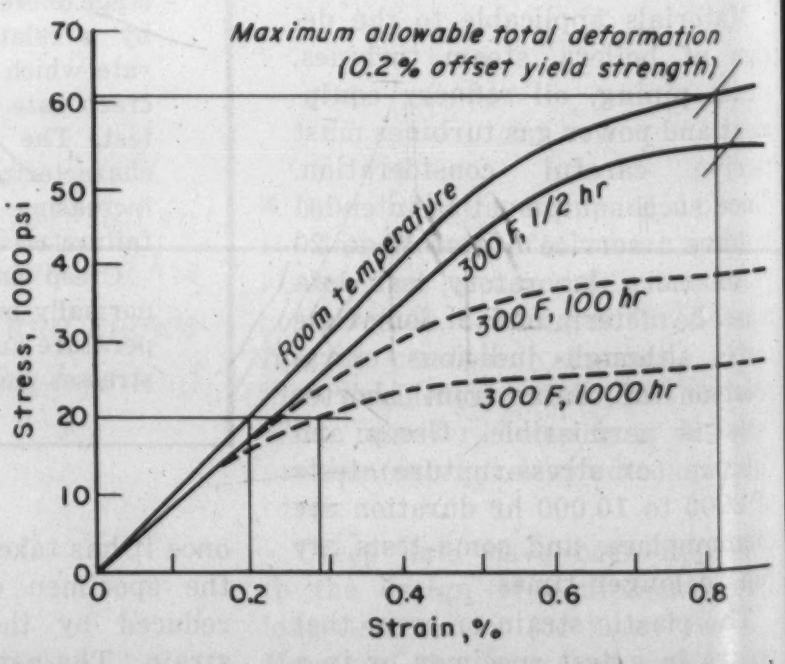


Fig 6*—Stress-strain curves at room temperature and 300 F, and schematic isochonous stress-strain curves at 300 F for an aluminum alloy.*

in design and for evaluating materials. It is the stress to produce a given amount of strain in a given time, e.g., 0.2% deformation in 500 hr. Data for this type of evaluation are obtained from creep-rupture and creep curves similar to those in Fig 2 (see box) and are plotted as shown in Fig 5. From this plot, the stress to produce 0.2% strain in 500 hr can easily be determined.

Creep in airframe structures

Conventional aircraft are designed to operate at atmospheric temperatures, and their design is based on conventional short-time stress-strain data obtained at room temperature. As long as aircraft operate at normal temperatures, creep is not a problem, but aircraft are now being designed to fly at supersonic speeds. At such speeds aerodynamic heating causes airframe temperature to increase to such an extent that creep must be considered.

The creep problem in a complicated structure such as a wing is quite different from the creep problems discussed earlier in this article. Normally, stressed parts at high temperatures are free to deform very much like a test specimen in the laboratory. However, a structure composed of tension and compression members cannot deform freely as can a turbine blade in a jet engine. Since the stressed members are restrained, some will be upset and others elongated, but the over-all dimensions may not change greatly until failure occurs suddenly and with little or no warning.

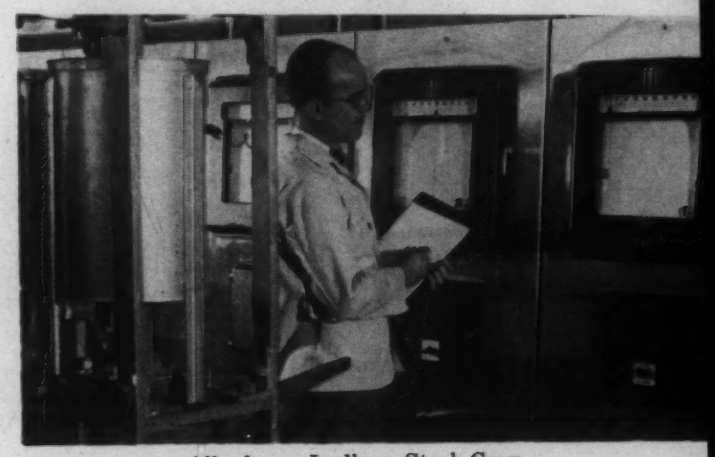
Airframes intended to operate at elevated temperatures will probably be designed very much as conventional airframes are, and the design then evaluated for creep. This approach seems necessary because creep data cannot be applied to the design formulas which must be used. The situation is similar to that of fatigue in conventional airframe design; airframes are difficult to design for fatigue, but the design can be evaluated for fatigue and modified if necessary.

To simplify the task of evaluating the airframe design for creep it is desirable to furnish creep data in the form of curves similar to those with which the designer is familiar. Fig 6 shows typical stress-strain curves for an aluminum alloy at room temperature and at 300 F, and isochronous (constant time) stress-strain curves for 100 and 1000 hr at 300 F. The isochronous curves are constructed from creep curves similar to those shown in Fig 2 by plotting the strain produced by different stresses at constant times. (The isochronous curves in Fig 6 are schematic and should not be regarded as actual test data.)

Within the straight-line portion of the stress-strain curves, stress is proportional to strain and the behavior indicated is elastic. At stresses above the straight-line portion of the curve, the amount of deviation from a straight line represents plastic strain or permanent deformation. (The 0.2% offset yield strength is the stress that produces 0.2% permanent deformation.) The relationship of isochronous curves to a stress-strain curve is such that the points at which the isochronous curves deviate (shown as dashed line in Fig 6) from the stress-strain curve indicate the stress at which creep becomes an important factor under the conditions of time and temperature for which the curves were prepared.

For example, an approximation of the amount of allowable deformation available to the designer of a bomber is given by Fig 6. If maximum allowable total deformation is the strain at 0.2% offset yield strength, this limit is about 0.8%. If the design of a conventional bomber is based on one-third of room temperature yield strength and on level flight conditions, exclusive of maneuver and gust loads, steady-state flight stress with this particular aluminum alloy is 20,000 psi and represents 0.2% strain. This point on the stress-strain curve is well within the region of elastic behavior and creep does not enter the picture.

Suppose, however, that the bomber is expected to be heated aerodynamically to 300 F. The design stress of 20,000 psi is then above the point in Fig 6 where the isochronous curves leave the straight-line portion of the 300 F stress-strain curve, and creep will occur. Under the minimum conditions of level flight, the 300 F 1000 hr curve indicates that approximately 0.3% strain will occur, leaving 0.5% strain remaining to reach the 0.8% limit. Since first-stage creep, which may be substantial, has not yet been added, and since maximum maneuver and gust loads may reach 40,000 psi, it is obvious that the bomber could not fly under these conditions for more than a few missions without exceeding the remaining 0.5% total deformation and running the risk of immediate failure.



Allegheny Ludlum Steel Corp.

Stress rupture testing *is used to obtain data for design of short-life equipment.*

Creep Is Only Part of the Problem

Many factors other than creep or rupture strength must be considered in selecting materials for use at high temperatures. Among them are properties such as oxidation or corrosion resistance, thermal expansion and conductivity, damping capacity, mechanical and thermal shock resistance, notch sensitivity, and behavior under cyclic stress and temperature. Availability and cost are also important.

Complex shape *of these stainless milking machine parts indicates degree to which mechanical tubing can be formed.*

Fabricating Mechanical Steel Tubing

Mechanical tubing is a versatile metal form which can be fabricated in many different ways. Here is the basic information on forming methods and their limitations that you need in designing tubular products.

■ In addition to outstanding strength and design flexibility, one of the most important reasons for the popularity of mechanical tubing is its adaptability to a wide variety of forming methods. Tubing is available in a multitude of shapes and sections and readily lends itself to such forming operations as bending, expanding, flanging, beading, upsetting and swaging.

Bending

Round tubing can be easily bent in any direction to form a full strength bend. Bends can be produced with or without mandrel support. During bending the outer wall is stretched and the inner wall is compressed. Because of this compressive action there is a tendency for buckles to form at

the inside of the bend. Consequently, a mandrel has to be used with light gage tubing to keep the metal smooth. The minimum radius to which a tube can be bent depends on the size, gage and ductility of the metal. This minimum radius is usually determined by the formula:

$$L = \frac{0.2468\,\pi\,(D^2-d^2)}{t}$$

where

L = Center line radius of bend
D = Outside diameter
d = Inside diameter
t = Wall thickness

Standard minimum center line radii for various diameters and thicknesses of round tubing formed without a mandrel are listed in Table 1. To prevent high scrap losses and to minimize the time required for forming operations, small radius bends should be avoided in light gage, large diameter tubing. Fabrication can be facilitated by using a tube with a heavier wall, smaller o.d. or larger radius.

When a mandrel is not used the minimum distance between bends in the same plane should be at least twice the tube o.d. (Distance between bends is defined as the length of the straight section between tangent points.) Minimum distance between bends in different planes should be three times the o.d. To maintain a true tube diameter at the ends, distance between the theoretical tangent point of a bend and the end of the tube should be twice the tube o.d.

Recommended minimum bend radii for mandrel tube bends are listed in Table 2. Methods for calculating minimum distance between bends and distance of bends from tube ends are the same as mentioned above, except that the distance between bends in different planes can be lowered to 2½ times the tube o.d.

TABLE 1—MINIMUM BEND RADII (IN.) FOR ROUND TUBING—WITHOUT MANDREL[a]

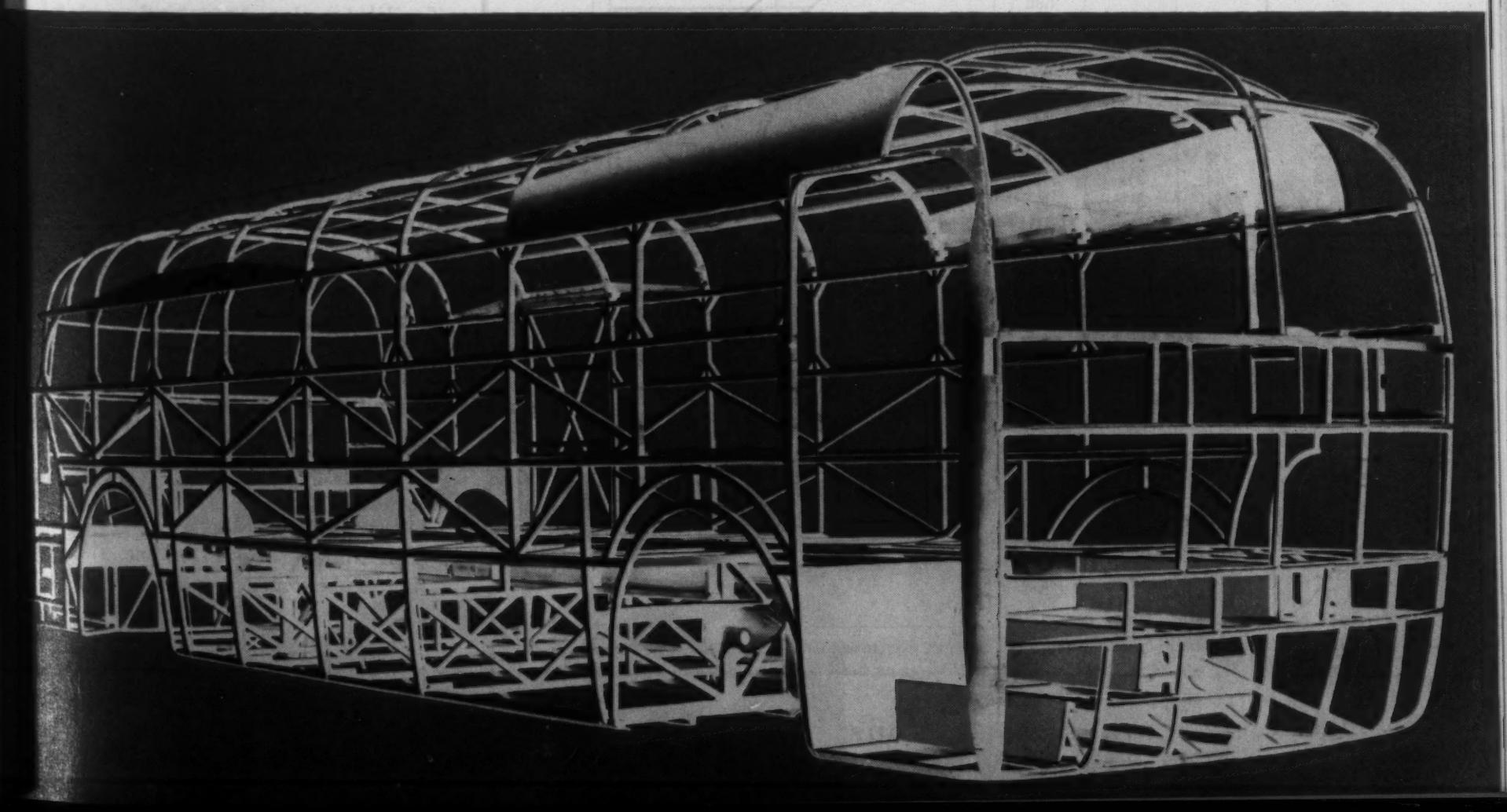
Outside Dia, in \ Wall Thk, in.	0.083	0.065	0.049	0.035	0.028
½	1¼	1¼	1½	1½	1½
¾	2	2	2¼	2¼	2¼
1	2¾	3	3	3	3
1¼	3½	3¾	3¾	3¾	3¾
1½	4½	4½	4½	4½	4½
1¾	5¼	5¼	5¼	5¼	5¼
2	6	6	6	6	—
2¼	6¾	6¾	6¾	6¾	—
2½	7½	7½	7½	7¾	—
2¾	8¼	8¼	8½	8½	—
3	9	9	9¼	9¼	—
3¼	9¾	10¾	10	—	—
3½	10½	11½	10¾	—	—
3¾	11½	12¼	—	—	—
4	12¼	—	—	—	—

[a] Data are applicable when o.d. of tube does not exceed 2½ in. and angle of bend does not exceed 90 deg; or when tube o.d. exceeds 2½ in. and angle of bend does not exceed 75 deg. Minimum radii for intermediate sizes can be computed by the standard formula.

TABLE 2—MINIMUM BEND RADII FOR ROUND TUBING—WITH MANDREL

Outside Dia, in.	Wall Th, in.	Min Rad
½–⅞	0.065	O.D. x 1½
	0.049	2
	0.035	2½
1–2¼	0.083	1½
	0.065	2
	0.049	2½
	0.035	3
2⅜–3	0.083	2
	0.065	2½
	0.049	3
3⅛–4	0.083	2½
	0.065	3

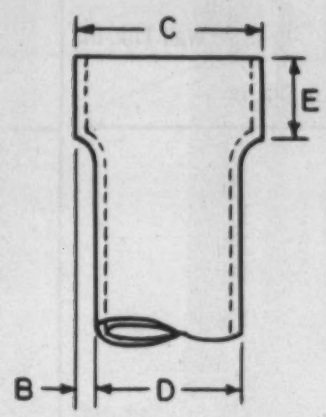
Complex structural design *obtainable with mechanical tubing is illustrated by this body framework for large bus.*



Typical Dimensions (in.) for . . .

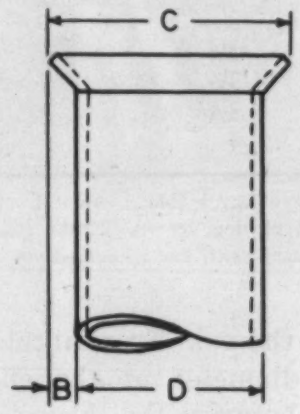
EXPANDED TUBING

D	B	C	E
½	1/32	9/16	¼-½
1	1/16	1⅛	¼-1
1½	3/32	1 11/16	¼-1½
2	⅛	2¼	¼-2
2½	5/32	2 13/16	½-2½
3	3/16	3⅜	½-2½
3½	7/32	3 15/16	½-2½
4	¼	4½	½-2½



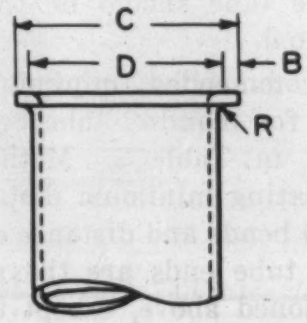
TUBING WITH 90-DEG FLANGE

D	B	C
½	1/32	9/16
1	1/16	1⅛
1½	3/32	1 11/16
2	⅛	2¼
2½	5/32	2 13/16
3	3/16	2⅜
3½	7/32	3 15/16
4	¼	4½



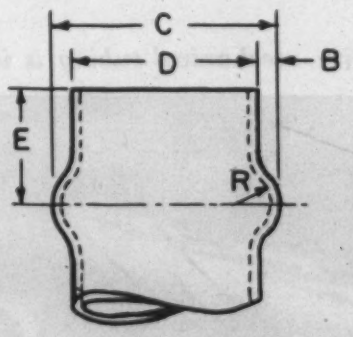
TUBING WITH 45-DEG FLANGE

D	B	C
½	⅛	9/16
1	1/16	1⅛
1½	3/32	1 11/16
2	⅛	2¼
2½	5/32	2 13/16
3	3/16	3⅜
3½	7/32	3 15/16
4	¼	4½



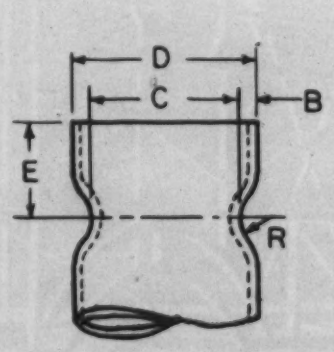
TUBING WITH EXPANDED BEAD

D	B	C	Min Rad	E
½	⅛	9/16	⅛	¼-½
1	1/16	1⅛	⅛	½-1
1½	3/32	1 11/16	3/16	½-1
2	⅛	2¼	3/16	¾-1½
2½	5/32	2 13/16	¼	1-2
3	3/16	3⅜	¼	1½-2½
3½	7/32	3 15/16	¼	1½-3
4	¼	4½	¼	½-3



TUBING WITH DEPRESSED BEAD

D	B	C	Min Rad	E
½	⅛	7/16	⅛	¼-½
1	1/16	⅞	⅛	½-1
1½	3/32	1 5/16	3/16	½-1
2	⅛	1¾	3/16	¾-1½
2½	5/32	2 3/16	¼	1-2
3	3/16	2⅝	¼	1½-2½
3½	7/32	3 1/16	¼	1½-3
4	¼	3½	¼	1½-3



Note: Dimensions apply to carbon steel tubing. For intermediate sizes use the formula B = D x 0.0625, where B = width of flange, bevel or bead on one side, and D = tube o.d.

In any tubing design it is important not to specify a vertical and horizontal bend at the same section. Such a design can be avoided by using an extra bend in another section of the tube. Adjacent bends in the same direction are impractical and should be avoided by specifying one compromise radius.

Bending is usually accompanied by a small reduction in cross section; however, contours can generally be held to ±⅛ in. Some wall displacement occurs in all tubular bends, especially mandrel bends. The amount of displacement will vary, depending on the equipment used and the analysis and mechanical properties of the tube. In typical tests made with a production run of 1010 steel (resistance welded, 2⅝ in. o.d. x 0.035 in. wall, annealed), a tube with a 90-deg bend was checked in the plane of the bend midway between the bend starting points. The wall of the tube at the inner radius showed an increase in thickness of 20%. Wall thickness on the center line radius showed an 8% decrease, and thickness of the wall at the outer radius decreased 30%. Ratio of tube o.d. to bend radius was 3:4.

Because the walls of square and rectangular tubing have a tendency to collapse during bending, tubing of this type is generally bent on mandrels. Split dies are employed almost exclusively to facilitate placement and removal of the tubing. The minimum bend radii required to prevent buckling and wrinkling are presented in Tables 3 and 4. Wrinkle-free bends with radii smaller than those listed can be made; however, special tooling is usually required and bending equipment must be in excellent condition.

Expanding, flanging, beading

The maximum width to which a flange, bevel or bead can be formed with carbon steel tubing (1010 or 1015) is usually calculated by the formula:

$$B = D \times 0.0625$$

where

B = Flange width on one side
D = Tube o.d.

and 12½% metal elongation is assumed.

Dimensional limits of these shapes for a number of the most commonly used sizes of tubing are listed in the accompanying box.

Cold swaging

Because it is extremely difficult to swage abrupt tapers, all tapers should be limited to about 4½ deg, or a total included angle of 9 deg. No hard and fast rule can be given for calculating the increase in wall thickness caused by swaging. If necessary, wall thickness can be controlled by swaging over a mandrel. Cold working generally increases the hardness and decreases the ductility of the tube. The extent of these changes depends on such factors as the degree to which tube diameter is reduced, original properties of the metal, speed of forming, resistance of the tube to swaging, and degree of taper.

Upsetting

Welded steel tubing can be upset by standard methods. Requirements vary primarily with the size and gage of the tubing. By using a sufficient number of operations, it is possible to completely close the end of a 1½-in. tube for a distance of 3 in. by upsetting and swaging. If necessary, wall thickness can be increased up to 50% to obtain increased strength at tube ends or an extra stock allowance for the cutting of threads.

TABLE 3—MINIMUM BEND RADII (IN.) FOR SQUARE TUBING—WITH MANDREL

Size of Square, in. \ Wall Thk, in.	0.083	0.065	0.049	0.035
½	1⅝	1¾	1⅞	2
¾	2⅝	2 13/16	3	3⅜
1	3½	3¾	4	4½
1¼	4 11/16	5	5⅝	—
1½	5⅝	6	6¾	—
1¾	7	7⅞	8¾	—
2	8	9	10	—
2½	10	12½	—	—
3	12	15	—	—
4	20	22½	—	—

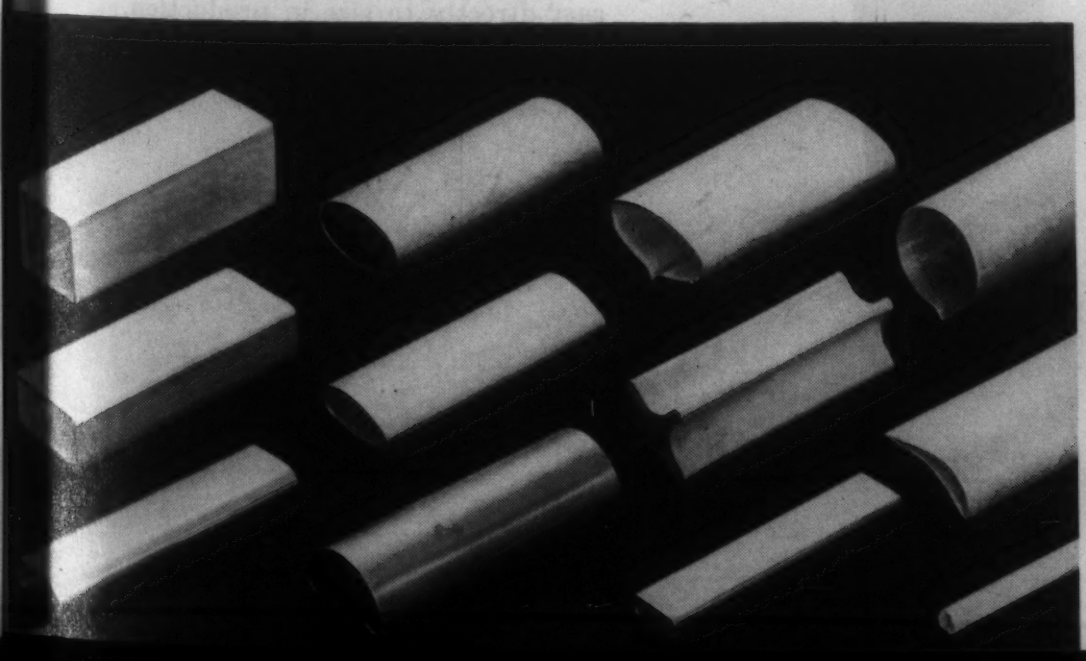
TABLE 4—TYPICAL MINIMUM BEND RADII (IN.) FOR RECTANGULAR TUBING—WITH MANDREL

Size of Rect, in.	Side of Bend Location	Wall Thickness, in. 0.083	0.065	0.049
½ x 1¼	½ in.	4 11/16	5	5⅝
	1¼	4 11/16	5	5⅝
¾ x 1¼	¾	5⅝	6	6¾
	1¼	4 11/16	5	5⅝
1 x 1¼	1	5⅝	6	6¾
	1¼	4 11/16	5	5⅝
1 x 2½	1	12	15	—
	2½	10	12½	—
1¼ x 1¾	1¼	8	9	10
	1¾	7	7⅞	8¾
1½ x 2	1½	10	12½	—
	2	8	9	—
1½ x 3½	1½	22½	24¾	—
	3½	16½	19¼	—
2½ x 4	2½	22½	24¾	—
	4	20	22½	—

Acknowledgment

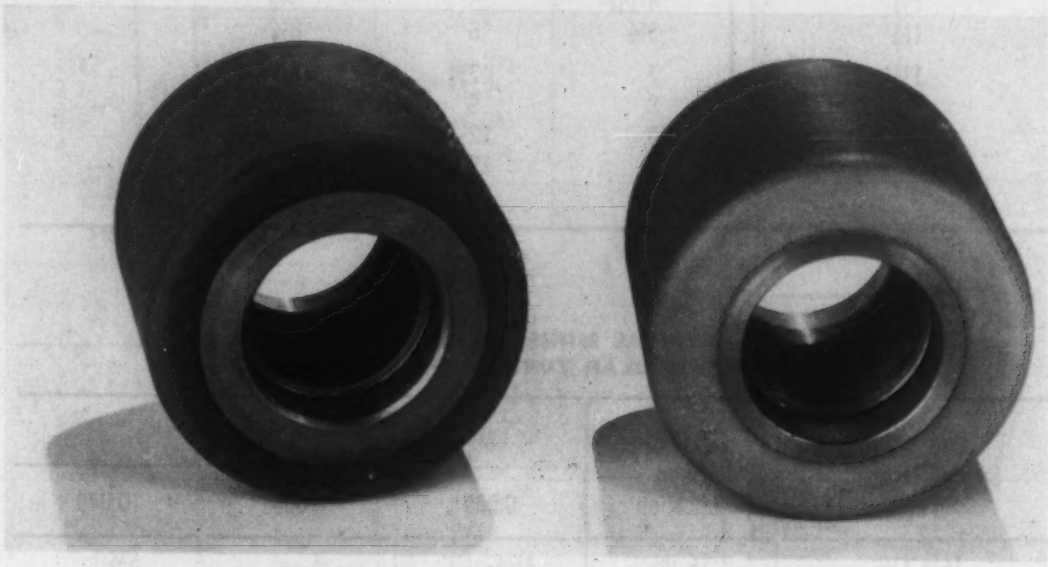
Adapted in part from the revised 1956 edition of the *Handbook of Welded Steel Tubing*. The cooperation extended by the Formed Steel Tube Institute in the preparation of this article is gratefully acknowledged. Although the data presented here was developed for electrically welded carbon and stainless tubing, it is generally applicable to all forms of tubing—welded or seamless.

Variety of cross sections *are available in stainless steel tubing for specialized applications.*

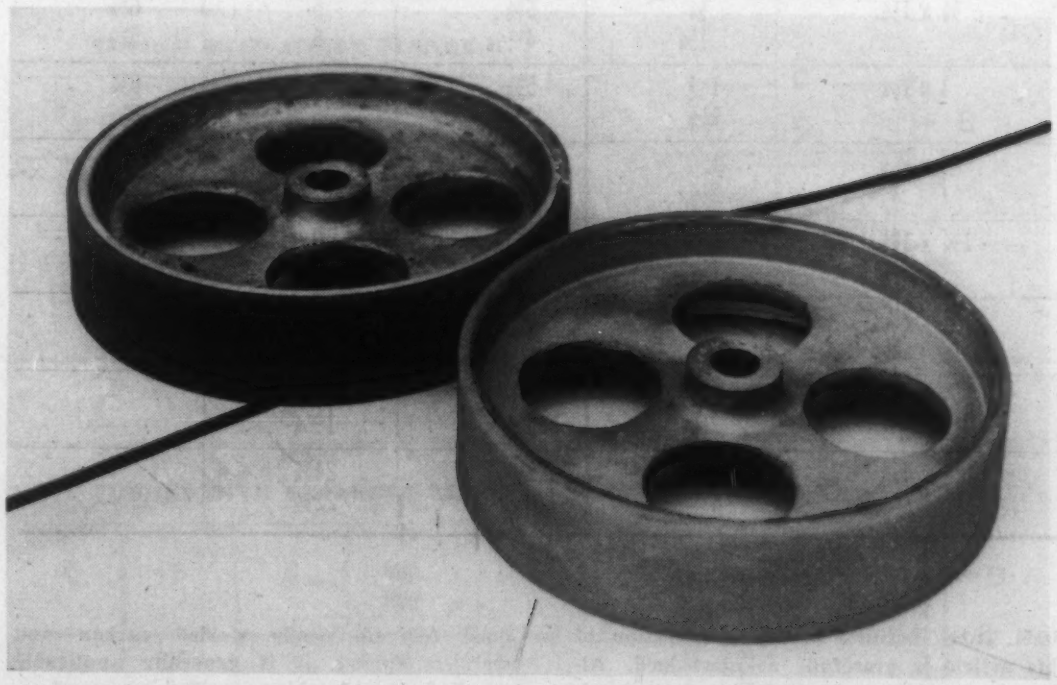


Variety of finishes *obtainable on carbon steel tubing is indicated by these round, square and rectangular shapes.*

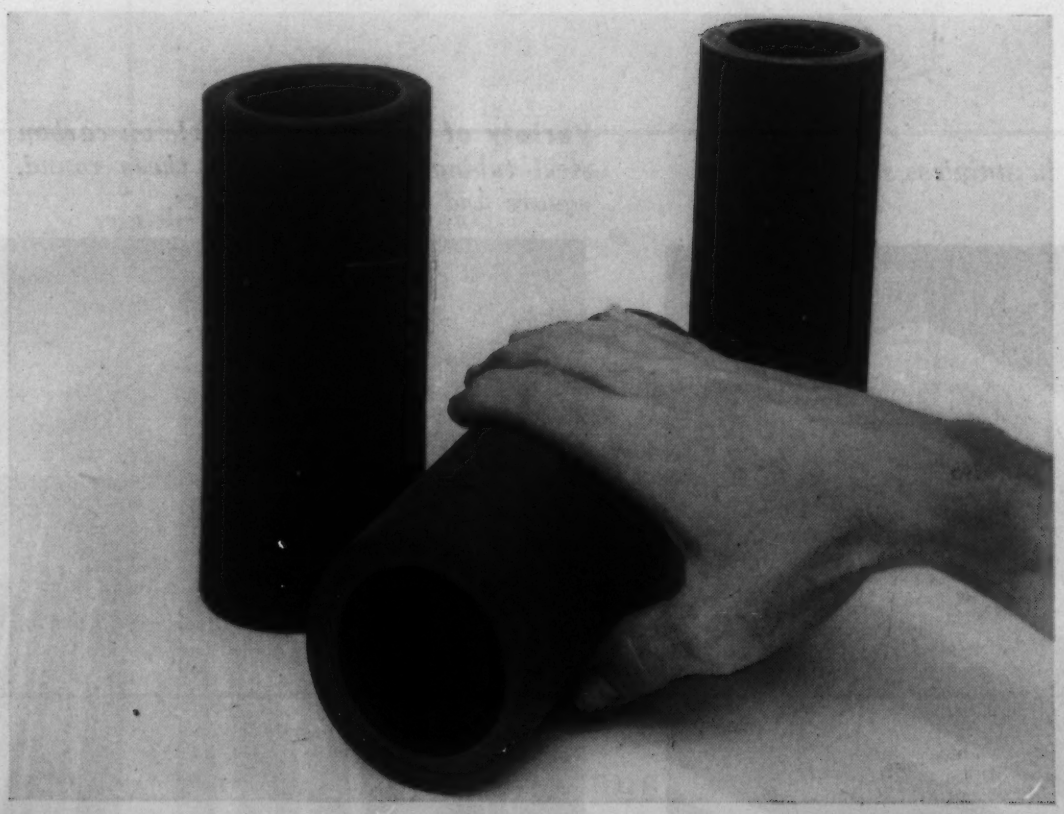
New urethane rubber finds use for . . .



Pallet wheel (left) for fork lift truck. It measures 4 x 3 in. and is cast. Former wheel (right) was made of butadiene-styrene rubber (GR-S) and had a ¾-in. rubber thickness and a ¼-in. hub rated at 400 lb capacity. The Disogrin wheel, rated at 2000 lb, has a ½-in. steel hub with only ½-in. rubber thickness. Reports from a leading fork lift truck manufacturer indicate that the new wheels will have a life many times that of the old wheels.



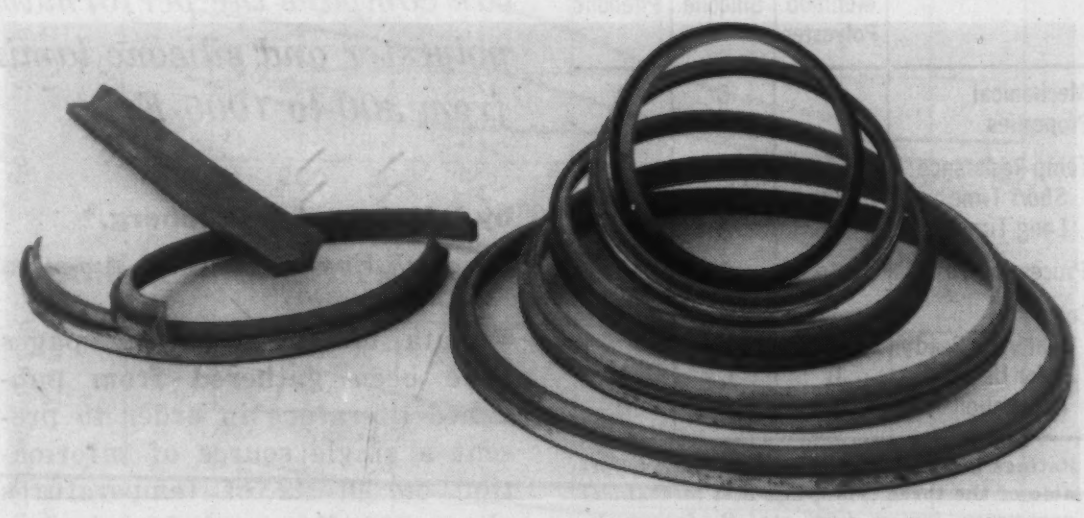
Wire counterwheels for a wire extruder. The wheels, cast and machined to accurate tolerances, have shown no appreciable wear after 6 mo operation at a feed rate of 400 fpm. Wheels shown are 5¾ in. in dia with ⅛-in. thickness of Disogrin. (Different colors are due to different lengths of exposure to sunlight.) Former wheels were stainless steel and required constant replating to size because of the error that wear caused in the count. The wheels were designed for Standard Machinery Co., Mystic, Conn.



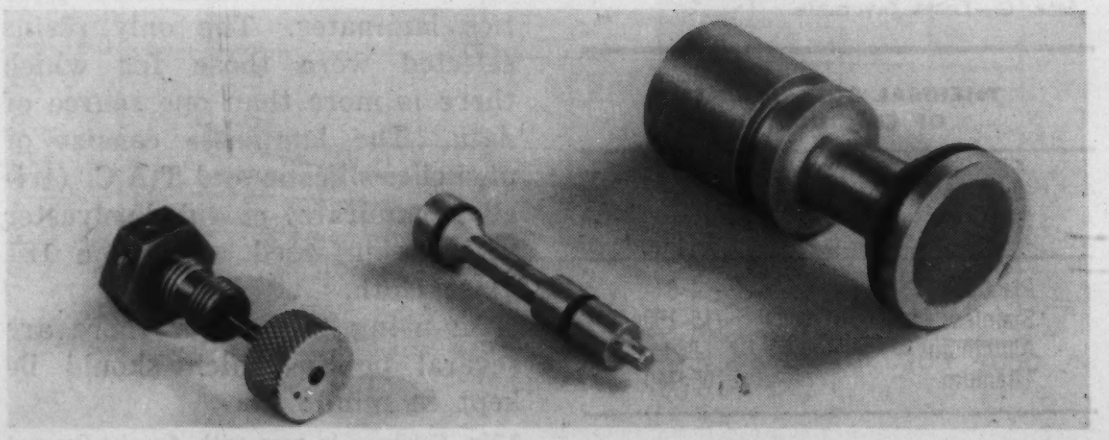
Spinning machine cots used for winding fiberglass. They have been used for 2 mo with a wear rate which indicates a 15 to 1 advantage over neoprene rubber. Cast and machined to size at present, the cots will be cast directly to size in production.

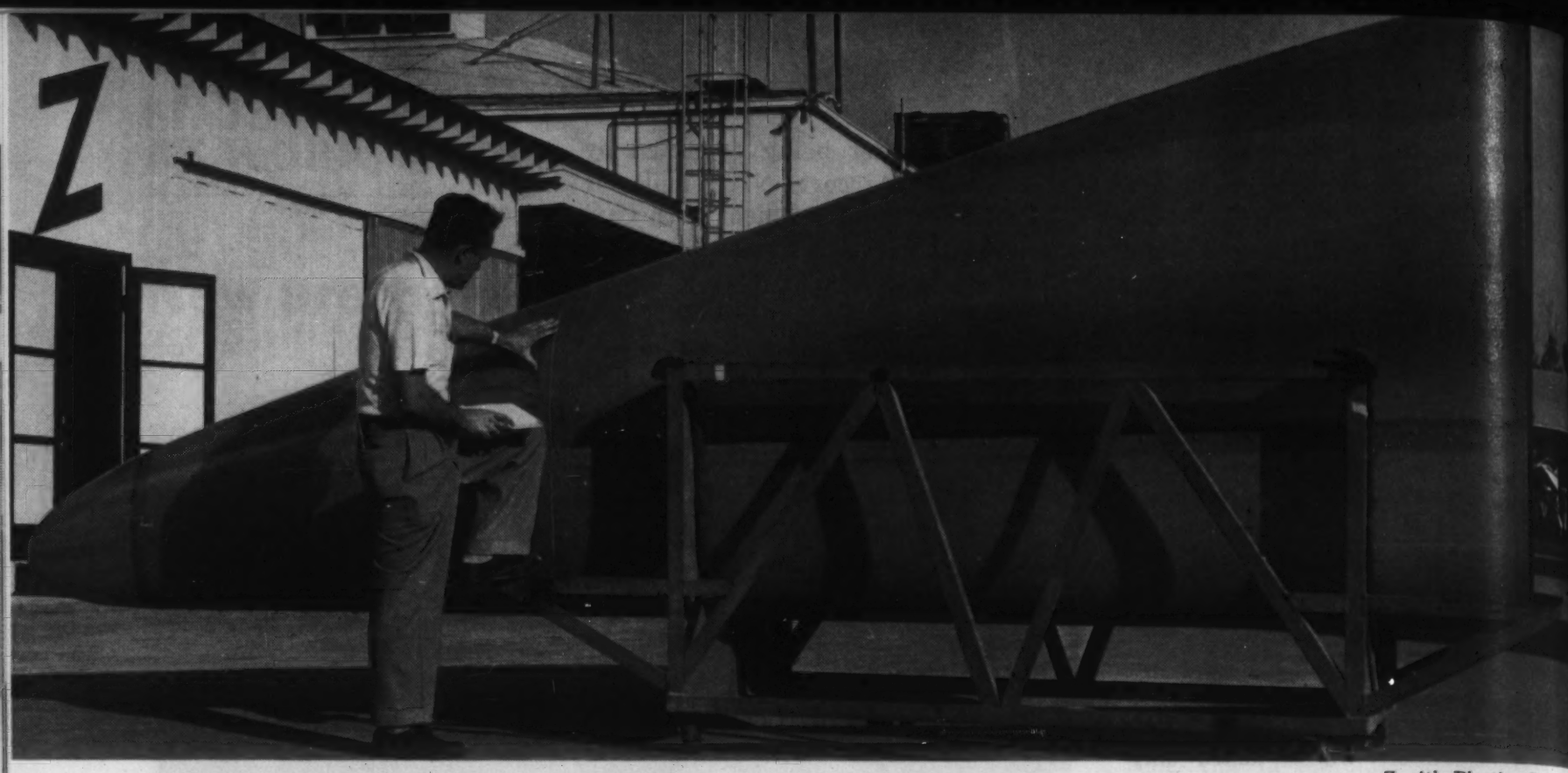
■ Disogrin, a diisocyanate polyester-based elastomer being produced by Greer Industries, Inc., New York International Airport, N.Y., under a Mobay Chemical Co. license and a technical assistance agreement with Carl Freudenberg (producer of Vulkollan) is said to offer high tensile strength, good abrasion resistance, good aging characteristics and resistance to oil, jet fuels, high ozone concentrations and radioactivity (see M&M, July '56, p 139). Both compression or injection molded and liquid cast parts are being manufactured for a variety of possible applications, some of which are shown here.

Contact wheel on belt grinder. The wheel, used at Greer, contains Disogrin cast directly onto hub to ⅛-in. thickness. After being used 1 mo it showed no measurable wear, although previous rubber wheels lasted only 3 mo. One of the most successful uses of Disogrin has been as a contact wheel for a turbine blade air foil grinder. It has proven possible to grind 4500 blades before changing wheels as against 50 previously. Made in a range of diameters from 0.96 to 2.50 in., the wheels are cast and finished ground to 0.0002 in. tolerance.



Machine tool protective pads and o-rings for poppet valve and gage contacts. The compression molded parts, made only for Greer use at present, have proved more inexpensive and efficient than rubber, bronze or steel. Use of an o-ring in the bleeder valve eliminated the lapping operation previously necessary. Diesel fuel, which caused rubber o-rings to swell, did not affect the Disogrin elastomer.





Zenith Plastics Co.

Use of plastics in aircraft structures *that are subject to steadily increasing service temperatures makes it important to know more about the . . .*

Elevated Temperature Properties of Reinforced Plastics

COMPARISON OF GLASS-REINFORCED PLASTICS LAMINATES[a]

	TAC—Modified Polyester	Silicone	Phenolic
Mechanical Properties	B	C	A
Temp Resistance:			
Short Time	C	B	A
Long Time	B	A	C
Processing Ease	A	C	B
Cost:			
Materials Ready for Use	B	C	A
Fabrication	A	C	B

[a] Ratings assigned as follows: A—most favorable of the three types, i.e., best mechanical properties, lowest cost, etc. B—Intermediate. C—Least favorable.

THERMAL COEFFICIENTS OF CONDUCTION

Material	K, Btu/hr/sq ft/F/in
Plastics	1-5
Stainless Steel	115-150
Aluminum	850
Titanium	105-120

On these four pages are curves representing data assembled from many different sources. By using these curves you can compare the performance of glass-reinforced phenolic, polyester and silicone laminates at temperatures ranging from 300 to 1000 F.

by I. Katz and J. Goldberg,*

Research Engineers, North American Aviation, Inc.

■ Data on the following pages have been gathered from published literature in order to present a single source of information on effects of temperatures above 300 F on reinforced plastics laminates. The only resins selected were those for which there is more than one source of data. The laminates consist of phenolic, silicone and T.A.C. (triallyl cyanurate)-modified polyester resins reinforced with type 181 glass cloth.

In using the curves there are several points which should be kept in mind:

1. *Primary value of curves is for comparison.* These data have been obtained mainly in research laboratories by research personnel and generally reflect manufacture under optimum conditions. Laminates made under production conditions may show a 10-30% drop in values. Accordingly, properties presented here should be used as an indication of order of magnitude or for comparison purposes, but not as a basis for design.

2. *Only one type of reinforcement is used.* Data are restricted to laminates reinforced with type 181 glass cloth—the type of re-

* Mr. Goldberg is now with Aerojet-General Corp.

inforcement generally selected for aircraft structures. Type 181 cloth provides essentially isotropic strength characteristics. For specialized purposes other fabrics are used. For example, type 143 glass cloth is used for laminates requiring a preponderance of strength in one direction. Type 112 glass cloth is used for laminates requiring an aerodynamically smooth surface.

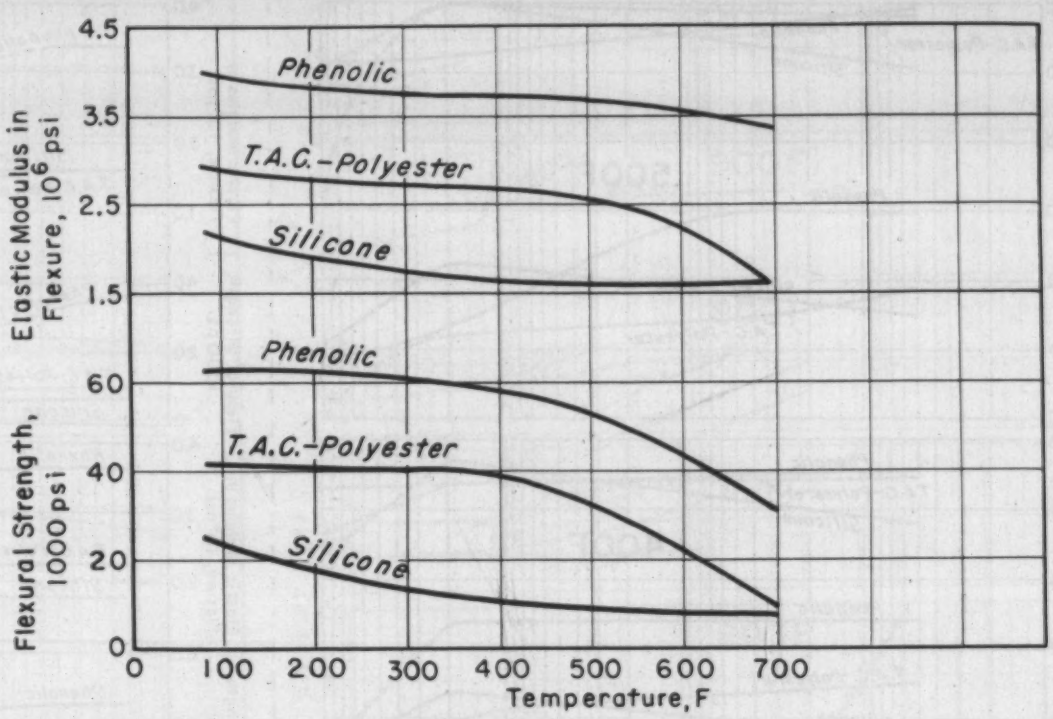
3. *Design of part affects choice of resin.* Characteristics inherent in resin types restrict the type of fabrication possible, and thus the design of the part itself. Phenolics and certain silicone resins give off volatiles during polymerization. Bleeders used to remove these volatiles cause a rough surface on one side of the laminate. Where two smooth surfaces are required platen presses can be used, although with thick parts they can cause high cost and quality problems since the volatiles are difficult to remove. TAC-modified polyesters do not liberate volatiles during cure. Consequently two smooth surfaces can be obtained by either vacuum bag or platen press techniques.

4. *Other basic attributes of laminates must be considered.* Each type of laminate has certain outstanding qualities. An accompanying table provides a general comparison of characteristics of each of the three types of laminates.

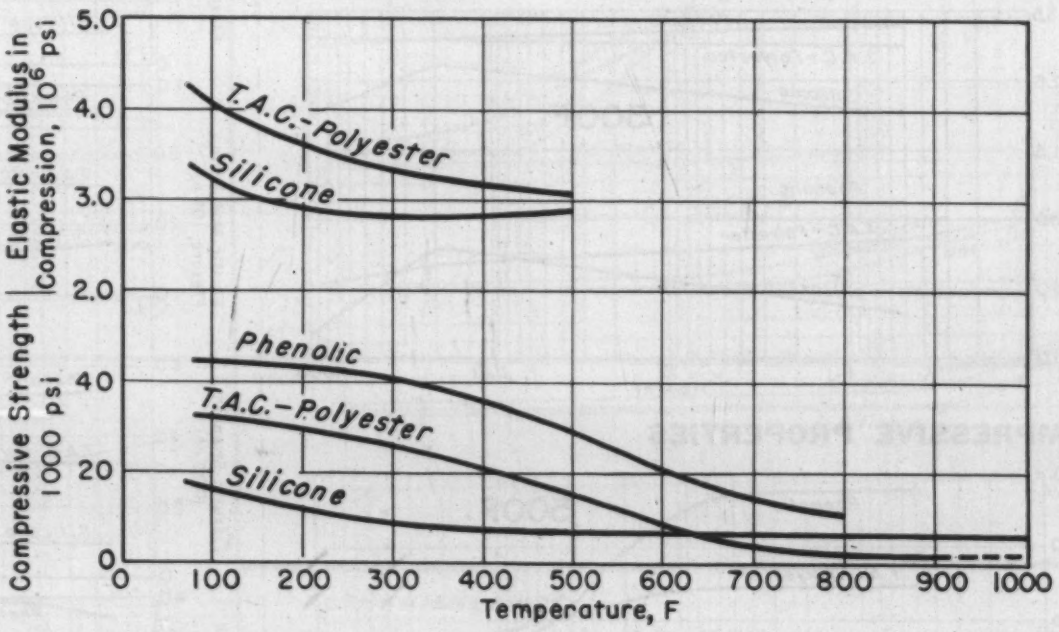
In evaluating laminates from the curves on the following pages the low thermal conductivity of plastics should be remembered. As an accompanying table shows, plastics' thermal conductivity is only a fraction of that of metals and such low values can be extremely useful in applications where a thermal block is needed for short periods of time. In certain applications where temperatures are in the order of thousands of degrees, plastics retain their structural integrity for short periods of time, during which metals would have become heated throughout to temperatures above their melting point.

Effects of Temperature on . . .

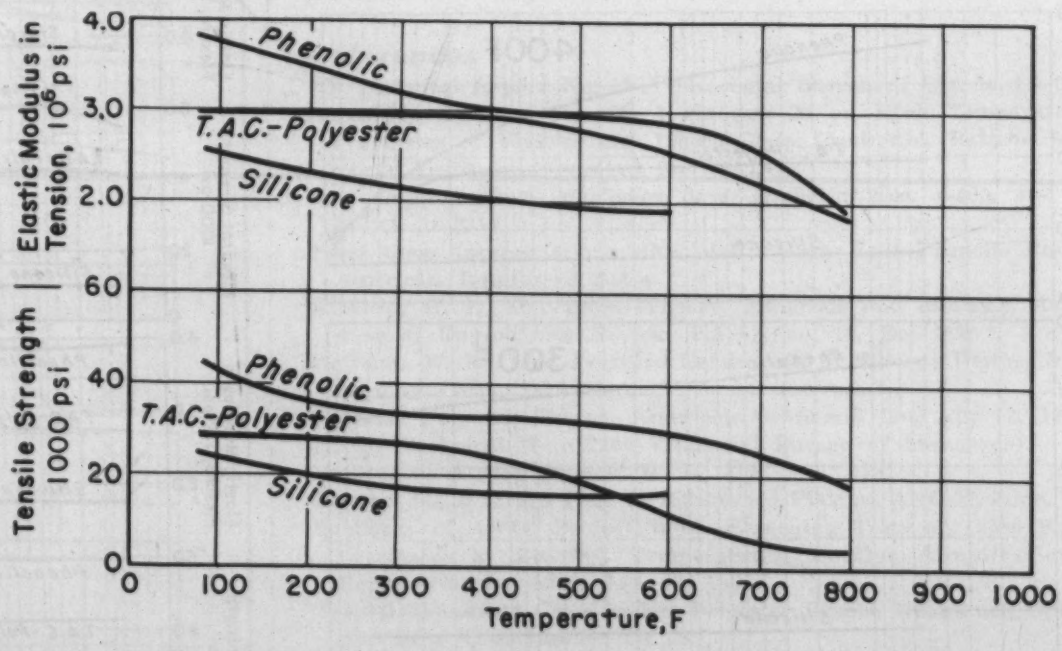
TENSILE PROPERTIES



COMPRESSIVE PROPERTIES

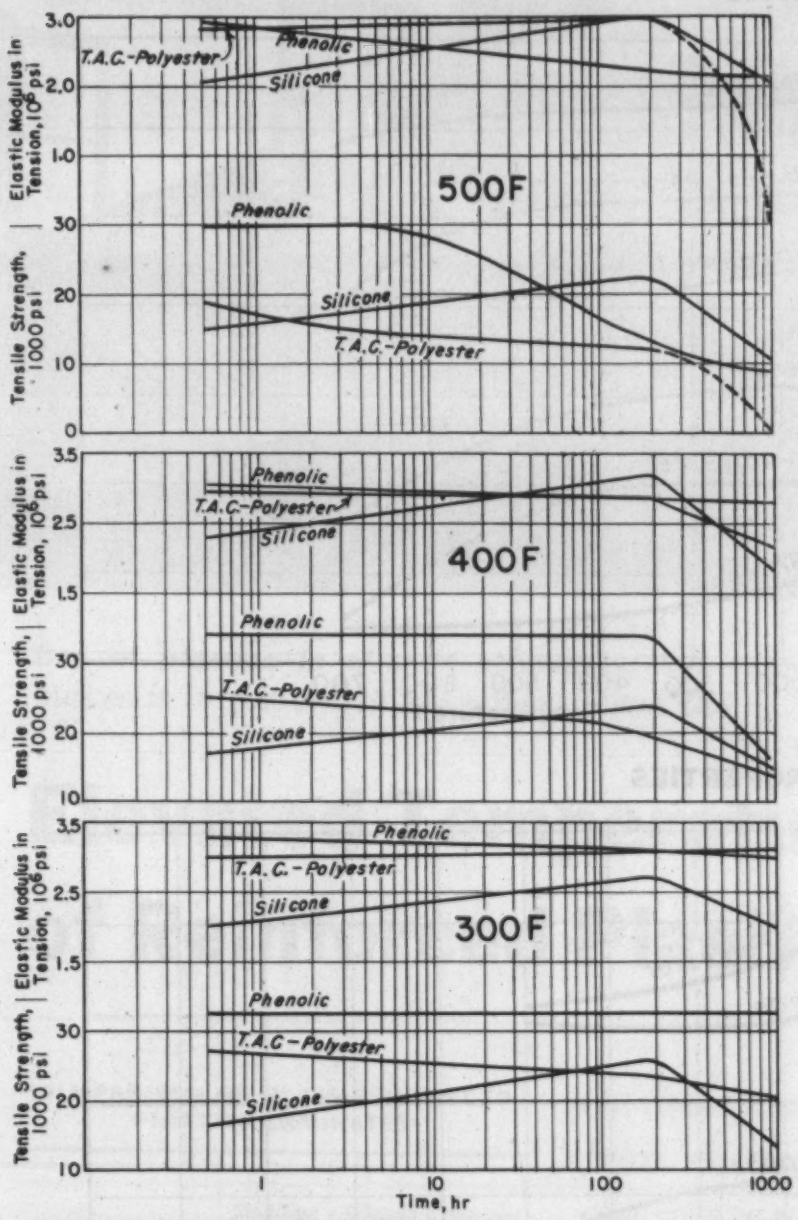


FLEXURAL PROPERTIES

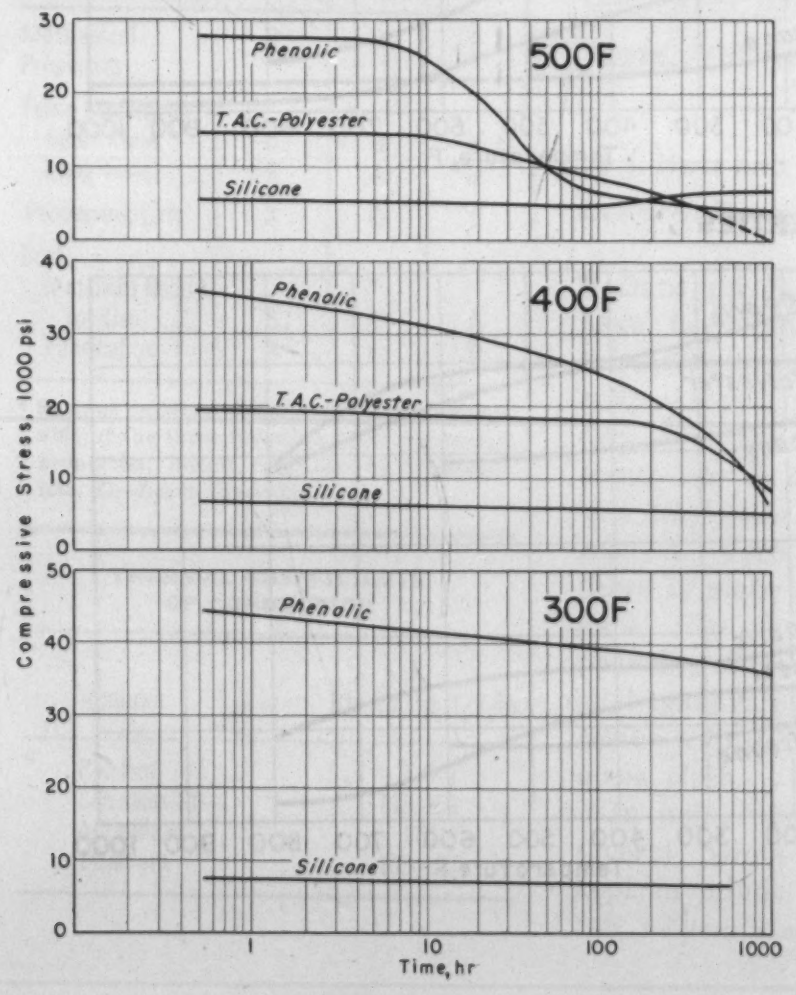


Effects of Time-at-Temperature on . . .

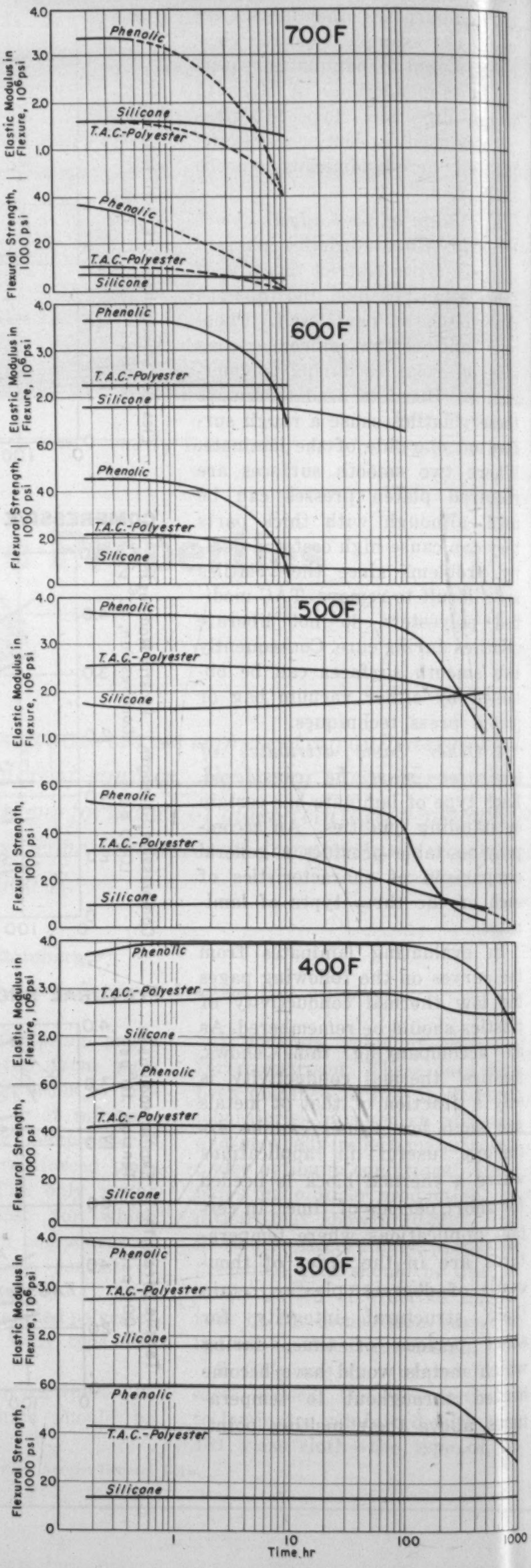
TENSILE PROPERTIES



COMPRESSIVE PROPERTIES

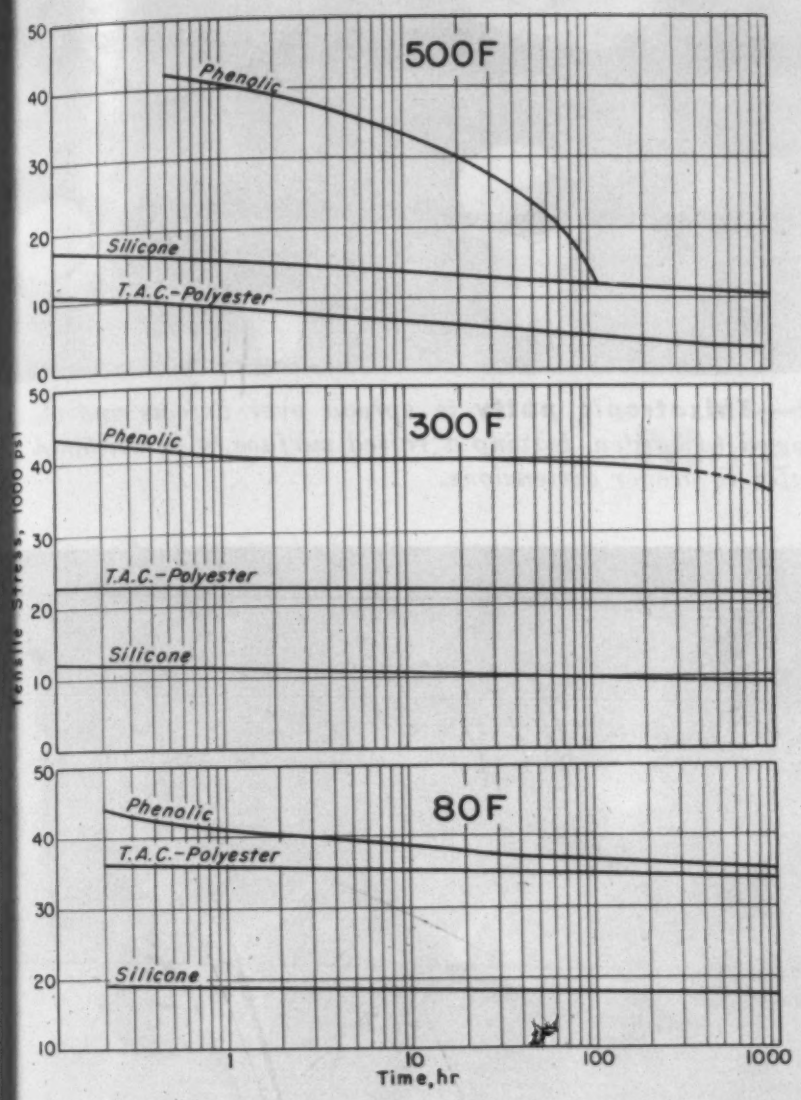


FLEXURAL PROPERTIES

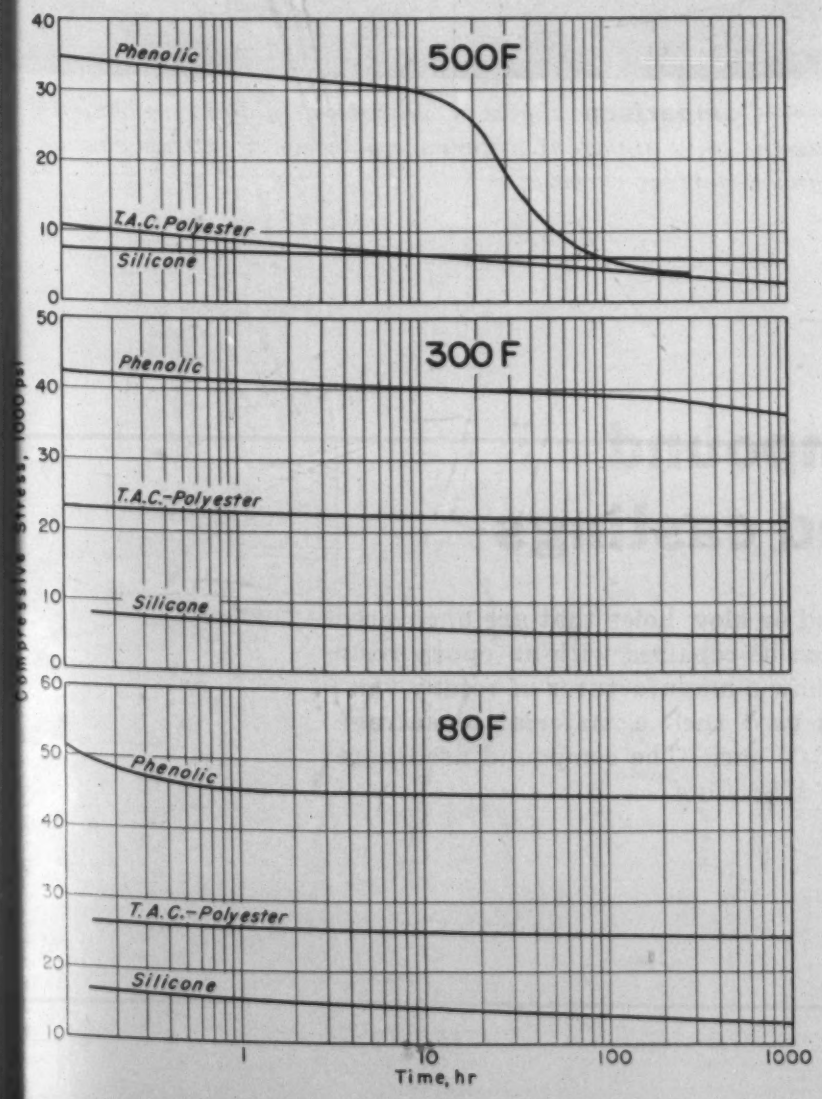


Creep-Rupture in . . .

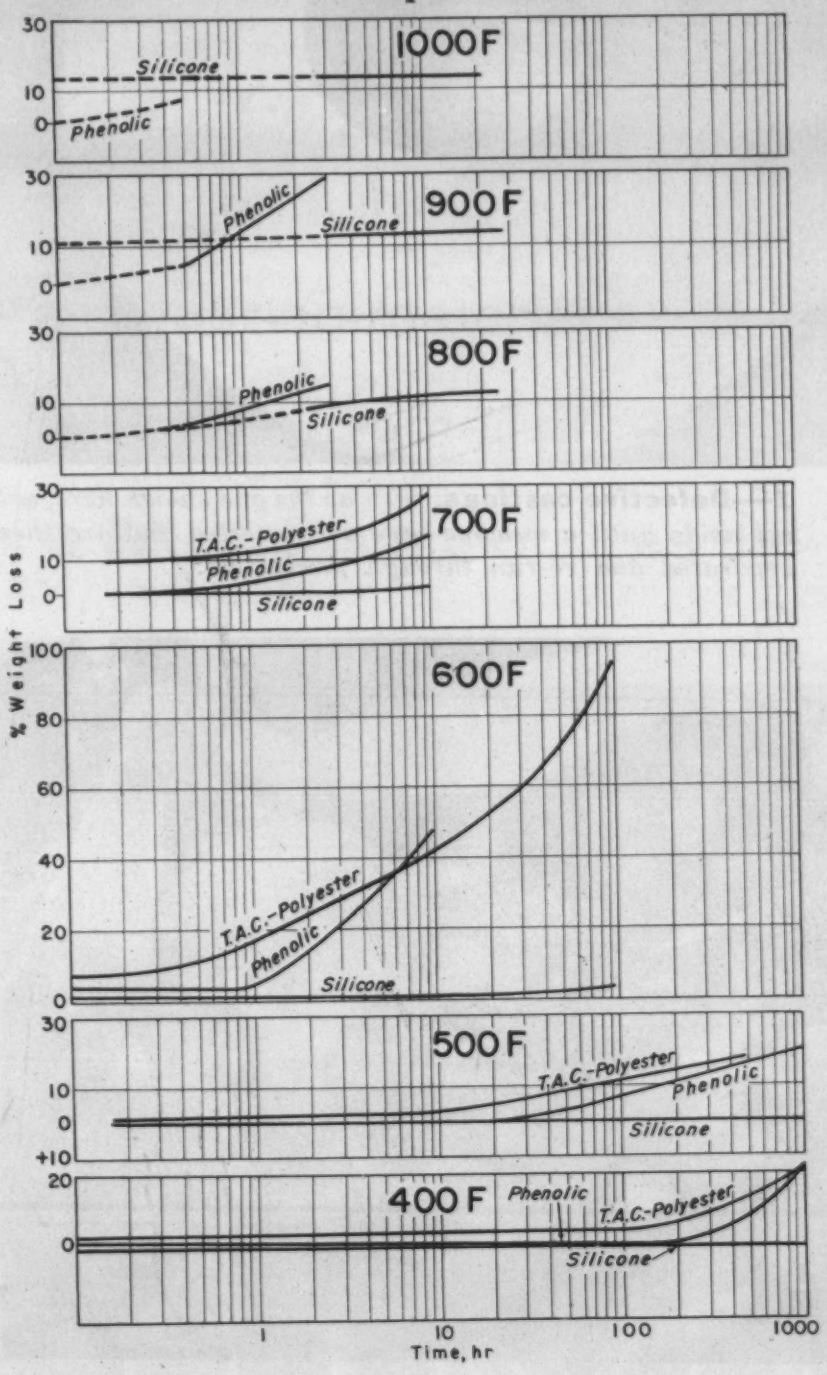
TENSION



COMPRESSION



Weight Loss During Exposures at Elevated Temperatures



Acknowledgment

The authors wish to thank M. A. Nadler, Missile Development Div., North American Aviation, Inc., for his critical evaluation and assistance in reviewing this material.

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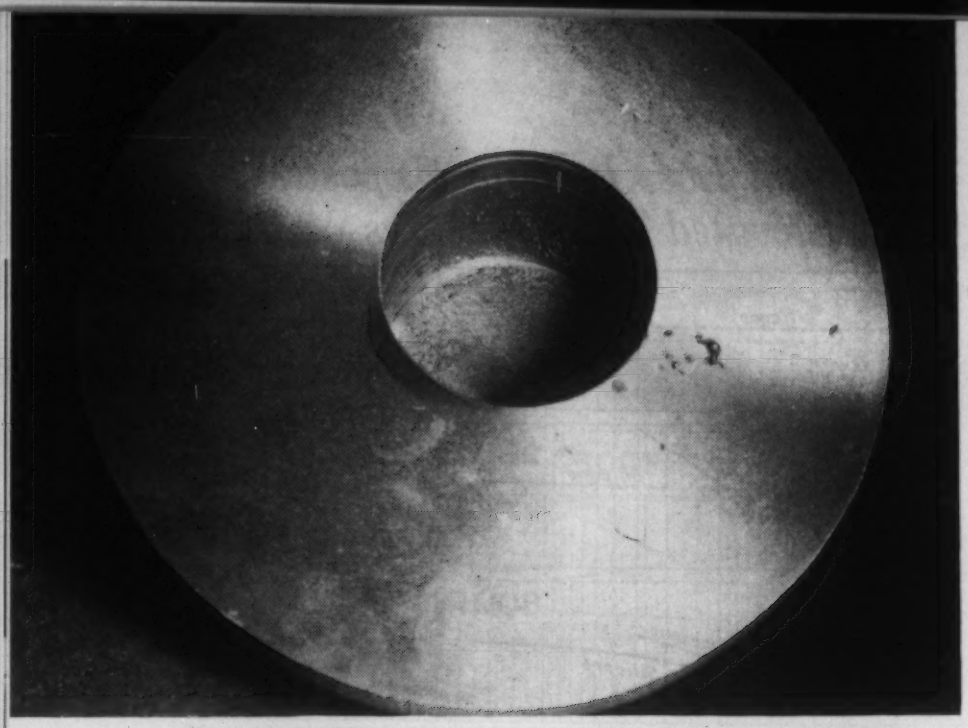
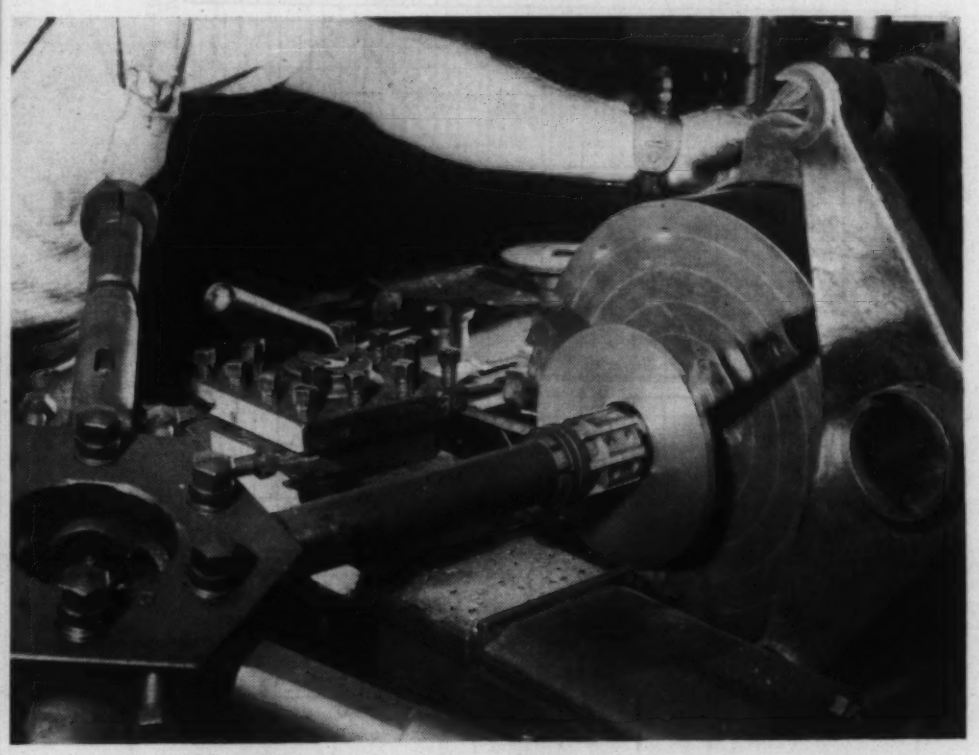
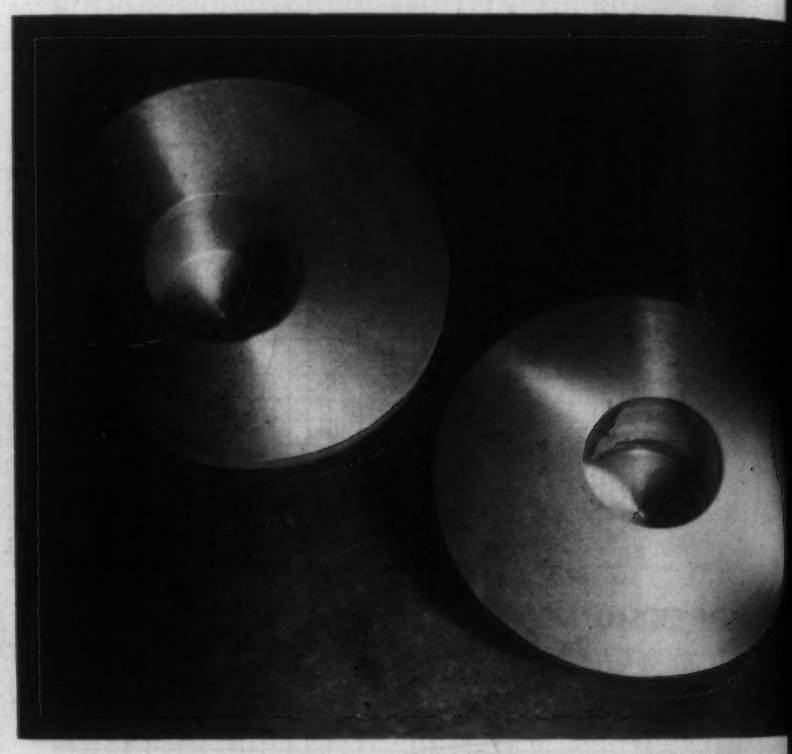


1—Defective castings, *such as the one shown here, are set aside until a number have accumulated and are then separated and re-run through production.*

2—Thixotropic putty *is spread over defects and allowed to harden, leaving a raised surface to be machined later to proper dimensions.*



3—Machining *the repaired casting requires no changes in cutting speed or tool advance and creates no perceptible difference in surface.*



4—Comparison *shows a variation in light reflectivity as the only apparent difference between a patched casting and a perfect casting.*

MATERIALS AT WORK

Epoxy resin compound repairs machined castings

Surface imperfections such as sand or blow holes that are uncovered in machining metal castings can often be repaired with an epoxy resin compound. These photographs show how a manufacturer of rotary-vane pumps for handling viscous liquids used such a material to salvage head well castings at a saving of $6.00 each. The compound used here is Metalset A2, made by Smooth-On Mfg. Co.

To encourage sound, imaginative and progressive use of engineering materials in the design and redesign of industrial and consumer products, **M**aterials & **M**ethods announces the

Materials & Methods AWARDS COMPETITION

for the

Best Use of Materials in Product Design

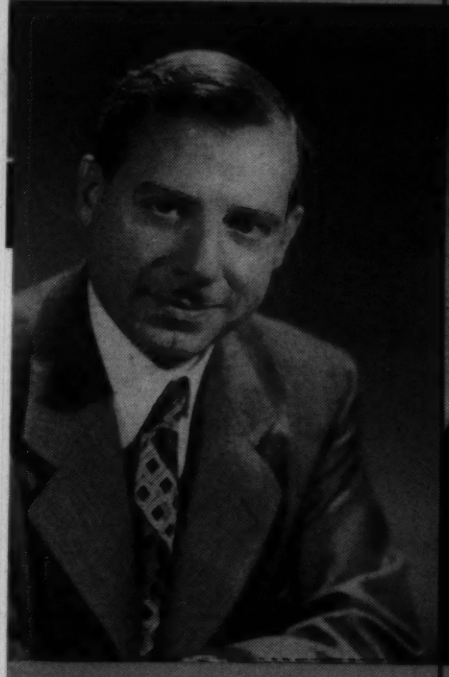
16 AWARDS for the Best Use of Materials in Product Design

The best entries selected by the judges will receive certificates plus cash awards as follows:

FIRST AWARD

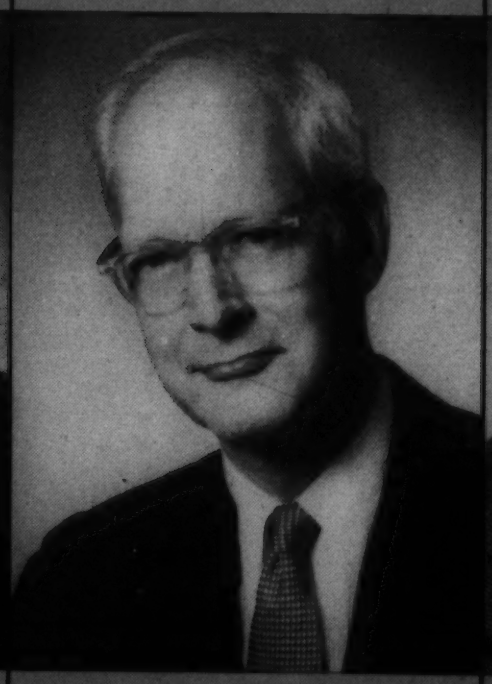
$500

BOARD OF JUDGES

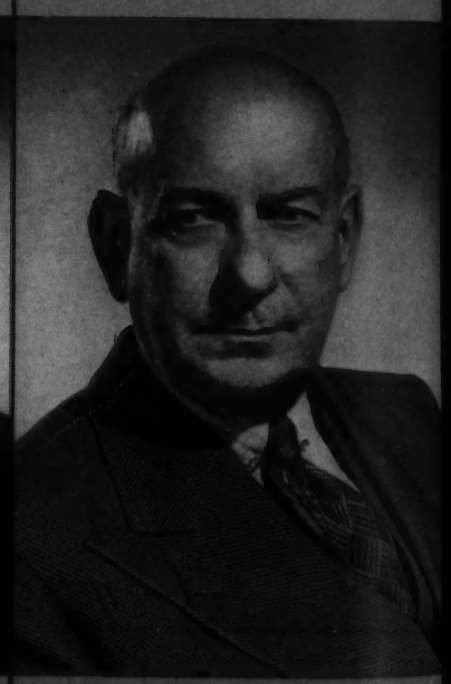


Joseph L. Bonanno
Chief Engineer,
Lionel Corp.

John P. Nielsen
Chairman,
Department of
Metallurgical Engineering,
New York University



John B. Seastone
Director,
Technical Division,
Olin Mathieson Chemical Corp.



Walter Dorwin Teague
Industrial Designer,
Walter Dorwin Teague
Associates

5 AWARDS OF MERIT

$100 *each*

10 CITATIONS

$50 *each*

Who may enter

Any person, persons, organization or consultants serving the product manufacturing industries may submit an entry or entries. Anyone employed by materials producers and suppliers is not eligible.

What may be entered

Entries may be either a new product or a redesigned product that demonstrates sound, imaginative and progressive use of engineering materials. Engineering materials are defined as metals, nonmetallics, finishes and coatings, and material forms (such as castings, forgings, moldings, fabricated shapes, etc.). The product may be a complete assembly, a subassembly, or a single part. See back page of this folder for details on the information that must be submitted with each entry.

When to submit entries

Any product(s) whose design or redesign was completed during the calendar year of 1956 may be entered. Entries must be mailed no later than January 31, 1957. Mail all entries to Awards Editor, Materials & Methods, 430 Park Avenue, New York 22, New York.

continued ⟶

When awards will be made

The awards will be made during the week of the Design Engineering Show, May 20-24, 1957, in New York City. The exact time and place will be announced in an early issue of Materials & Methods.

How to Prepare Your Entries

Entries need not be written up in the form of an article. They will not be judged for literary quality. However, the following information must be provided with each entry in order to allow the judges to make competent decisions.

1. A detailed description of the product including photographs or drawings. If the entry is a redesign, provide before and after illustrations if possible.
2. A description of requirements in service and/or fabrication that must be met by the product and the material.
3. A description of the previously used materials (if entry is a redesign).
4. A description of the material or materials selected for the product entry.
5. An explanation of why the material or materials were selected for the product. Describe the advantages or benefits gained through the choice. Back them up with evidence — facts, data, charts, tables on performance, quality or cost.

In general, entries should show that the materials selected for the product —

1. Resulted in improved performance and/or lower costs

or

2. Best met the design and service requirements.

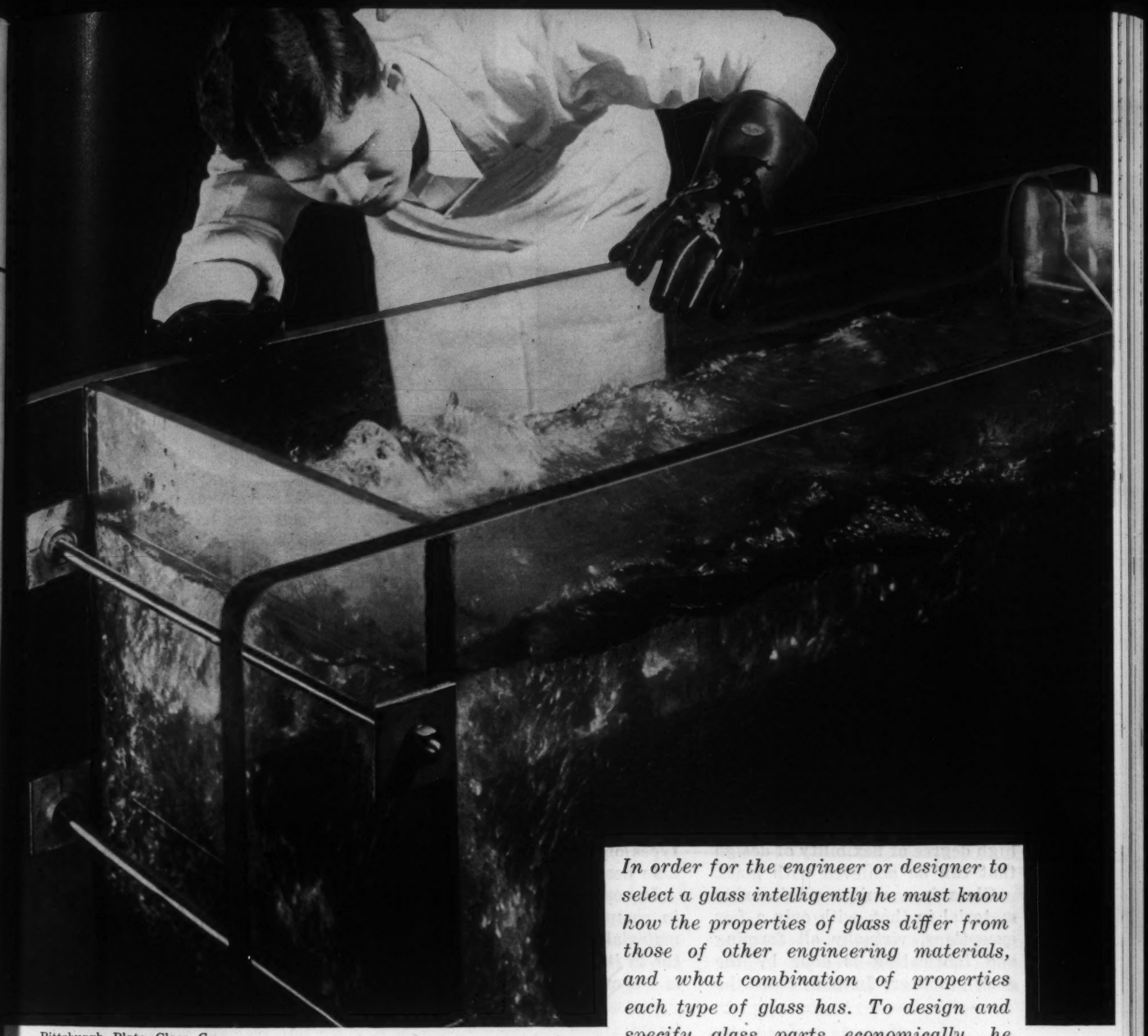
Here are a few specific ways in which a product can benefit from intelligent materials selection:

Longer service life	Improved service performance
Lower basic materials costs	Reduced scrap
Less material required	Reduced or eliminated maintenance
Improved appearance	Permitted lower cost design
Permitted a new design	Allowed greater design flexibility
Reduced production costs	Simplified production and fabrication

Remember! The more detailed and documented your entry is, the more consideration it will receive from the judges.

Publication of Entries

The award winning entries will be published in the May Design Engineering Show issue of Materials & Methods. Other entries not winning awards may be published at the discretion of the editors of Materials & Methods. Non-winning published entries will be paid for at the usual rate.



Pittsburgh Plate Glass Co.

In order for the engineer or designer to select a glass intelligently he must know how the properties of glass differ from those of other engineering materials, and what combination of properties each type of glass has. To design and specify glass parts economically, he must know in what form each combination of properties is commercially available. This manual is intended to aid the designer or engineer in selecting and specifying glass by providing information on:

- *Physical and Mechanical Properties*
- *Forms Commercially Available*
- *General Design Recommendations*
- *Characteristics of Specialty Glasses*

by M. W. Riley, *Associate Editor, Materials & Methods*

How to Select and Specify Glass

MATERIALS & METHODS MANUAL NO. 132—NOVEMBER 1956

Libbey-Owens-Ford Glass Co.

Plate glass, *laminated and heat treated, is used for glazing supersonic aircraft. Note wires at top connected with layer of electrically conductive glass for anti-icing and defogging.*

Corning Glass Works

Tubing *is the form of glass most commonly shaped and fabricated by the end-user. Here fluorescent tubing is being inspected.*

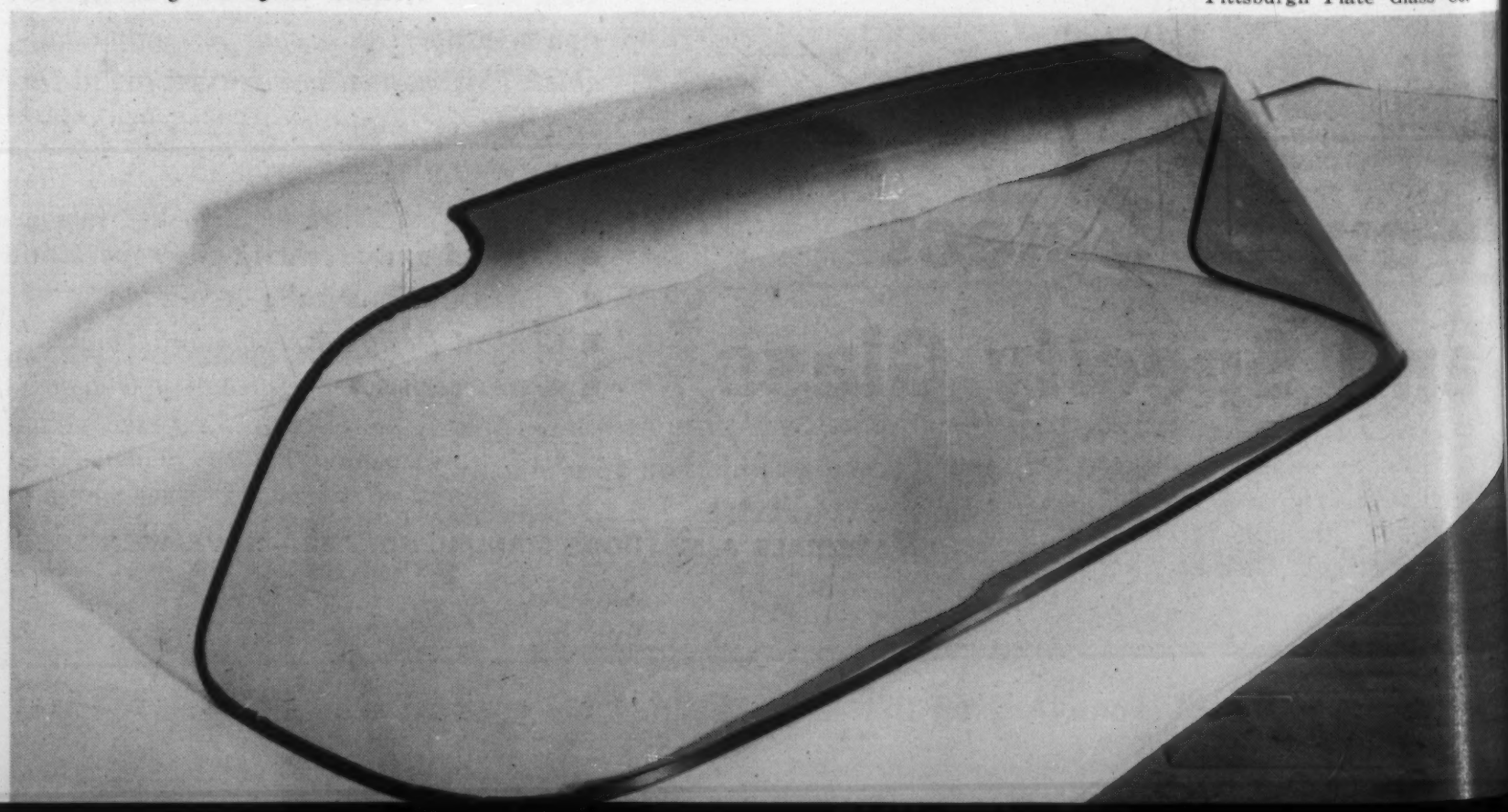
■ Important characteristics that make glass attractive to product designers are its inertness, its light transmission and absorption characteristics, its excellent dielectric properties and its good mechanical strength. Coupled with these physical properties is the high degree of flexibility of design that can be achieved with glass.

Glass is a unique engineering material in that, with only a few exceptions, virtually all forming and fabricating is done by the glass producer. In many cases the producer actually designs the product to meet requirements of the end user. However, for the designer or engineer to intelligently investigate the possibility of using glass, he should know 1) something of the general nature of glass, 2) the properties of various types of glasses, and 3) the available design shapes.

In some cases the cost of glass in comparison with an alternate material may be the deciding factor in its use. In other cases cost is comparatively unimportant, since the material which best meets design requirements is always the "least expensive." Cost of glass products depends on the type of glass used, but more often on the form in which it is purchased. If design requirements can be met by a glass product, quantity-produced in stock form, costs can be extremely low. If the product must be custom formed, the cost can be extremely high. The tables in the custom formed glass section indicate general economical production quantities for each type of ware.

Compound curvatures, *though difficult to achieve, can be formed in flat glass as shown by this windshield for the 1957 Mercury Turnpike Cruiser.*

Pittsburgh Plate Glass Co.



Types of Glass

Glass is a noncrystalline material produced primarily from inorganic oxides. Usually silica or sand is an important constituent. Other common glass formers are oxides of boron and phosphorus. Other oxides in glass act as modifiers of the glassy network.

Principal types of glass are:

Silica—Composed of pure fused silica without any other constituents, silica glass is used in the ultrasonics field for delay lines, in the optics field for prisms and wind tunnel windows, and in the ultra violet field for instrumentation. Its high purity makes it suitable for use as crucibles for such materials as germanium.

96% silica—Similar to silica glass in many properties, 96% silica glass is formed by leaching from borosilicate glasses most of the fluxing oxides, then firing at a high temperature. It is used for applications where temperatures may range between 500 and 1650 F and where high thermal shock is encountered, such as in thermocouple tubes and furnace sight glasses; or where a high degree of chemical resistance is required, such as in chemical reaction vessels; or where high ultraviolet transmission is required, such as in tubes for germicidal lamps.

Soda-lime — Accounting for about 90% of glasses melted today, soda-lime is economical both to melt and to fabricate. It is used for such products as containerware, flat glass, light bulbs and sight-correcting lenses. Where its properties are suitable, soda-lime is the most economical and easiest glass to use. In comparison with most other glasses, soda-lime glasses in general have higher thermal expansions, lower chemical resistance and lower dielectric properties.

Lead-alkali silicate—By replacing the lime in soda-lime glass with lead oxide, workability, electrical resistivity and brilliance of the glass are improved. The brilliance, high refractive index and improved workability are put to use in artistic ware, thermometer tubes, etc. The high electrical resistivity is put to use in critical electronic applications.

Borosilicate—Boric oxide is used both as a glass forming material and as a fluxing material for the silica in borosilicate glasses. These glasses have high melting points, low coefficients of thermal expansion, high chemical resistance and good electrical stability, making them well suited for use in oven ware, laboratory ware, electrical insulation, gage glasses and industrial piping.

Alumino-silicate — High softening point and low coefficient of thermal expansion make aluminosilicate glasses suitable for high temperature applications, and where thermal shock may be encountered. They are used for household cooking ware to be used over direct heat, high temperature thermometers, and water-level glasses for high-pressure steam boilers. They are somewhat harder to work than the borosilicate glasses.

Properties of Glass

Properties of glass cover a wide range and are based primarily on the composition of the glass, rate of solidification, condition of the glass surface and thermal treatments applied after forming. Since the properties of each of the six major types of glasses (except the fused silica) can be widely varied, Tables 1 and 2 list properties of representative formulations only.

Corrosion resistance

Glass is one of the most inert materials known. In general, it is measurably affected only by hydrofluoric acid, hot concentrated phosphoric acid, alkaline solutions and superheated water. Table 3 lists durability of glasses in various corrosive materials. Borosilicate and high silica glasses are most resistant to chemical attack.

Hydrofluoric acid and hot concentrated phosphoric acid cause serious attack. Cold alkaline solutions, dilute or concentrated, attack glass slowly, but as temperature increases, the rate of corrosion increases rapidly. Fig 1 shows the increase in rate of attack with increased alkalinity of solution. Fig 2 shows rate of attack by sodium hydroxide solutions of various concentrations and by water with increasing temperature. Both curves were obtained with a borosilicate glass. Agitation of the corrosive fluid intensifies the attack.

Attack by other reagents compares with that of sodium hydroxide about as follows: potassium hydroxide is about the same; lithium hydroxide is about 50% as severe; sodium carbonate is about 20% as severe; and ammonium hydroxide is about 5% as severe.

Although glass is attacked by water at temperatures above 300 F, attack is not severe enough to eliminate its use in applications such as boiler sight gages. Attack is speeded by higher alkalinity of water, and by designs that allow excessive condensation to form on the glass above the water line.

Mechanical strength

For design purposes glass is a perfectly elastic material. That is, it has no yield point but exhibits elastic behavior right up to the rupture stress. Furthermore, glass always breaks in tension, never in compression. Even when the breaking stress is applied in compression, there is always a tensile factor involved in fracture.

Intrinsically, glass has an extremely high tensile strength, on the order of three million pounds per square inch. However, actual strength is primarily dependent on surface conditions. Even a microscopic imperfection causes a high stress concentration and reduces

useful strength values to a fraction of theoretical. Actual tensile values taken from a large group of samples show a wide scatter due to this dependence on surface condition.

When designing with glass for structural uses, it is customary to adopt a maximum working stress in tension of 1000 psi for annealed glass and 2000 to 4000 psi for heat treated glass. These values include adequate safety factors.

Since even normal handling produces stress concentrations that reduce usable strength, the more abrasion resistant glasses, such as the borosilicates, usually give better mechanical service. Other than that, composition has little effect on strength of glass.

Modulus of elasticity of glasses ranges from 6 to 13 x 10^6 psi, though moduli commonly fall between 9 and 10 x 10^6 psi. Tables 1 and 2 list moduli of typical glasses. Elastic moduli for most glasses decrease with increase in temperature, with the exception of silica and low expansion borosilicates. Poisson's ratio for most glasses at room temperature ranges from 0.20 to 0.25, though that of silica glass is 0.17 and that of 96% silica is 0.18. Poisson's ratio for some specific formulations may be as high as 0.30. However, for most design purposes 0.22 can be used.

Fatigue

Fatigue in glass is extremely hard to measure, and for most purposes the engineer need not be concerned with it. However, glass is subject to fatigue and suffers loss of strength with increasing time under either cyclic or static loads. Water vapor in the atmosphere accelerates fatigue. Temperature also has an effect, though data are not conclusive. Long time strengths seem to be greater at low temperatures, decreasing with rising temperatures to a minimum value at about 200 to 350 F. Above this temperature range strengths seem to increase. Breaking stresses increase sharply with reduction in temperatures below 32 F.

Mechanical hardness

In the glass industry the terms *soft* and *hard* are used to define low and high temperature softening glasses. Consequently, the term *mechanical hardness* is used to avoid confusion. Mechanical hardness of glass is a critical property due to the direct relationship between abrasions or surface imperfections and the strength of glass. In general, glass has a relatively high mechanical hardness.

There are three common methods of measuring mechanical hardness of glass:

Scratch test—Values are measured on Moh's scale, and glass is usually rated between 4½ and 6 which is harder than calcite and fluorite but softer than quartz, topaz and corundum. Moh's scale has been criticized because intervals between gradations are not uniform.

Grinding test—Values represent amount of glass removed per unit of time. Values are inversely proportional to the mechanical hardness of the glass.

Indentation test—The Knoop, Vickers or Monotron test can be used to obtain hardness numbers corresponding to the total area deformed by a loaded indentor. Knoop hardness values for glasses range from 324 to 570 kg per sq mm. Fig 3 correlates mechanical hardness with modulus of elasticity.

Coefficient of friction

Though glass has a relatively smooth surface, glass-to-glass frictional coefficients are about the same as those of metal-to-metal mating. Coefficients of friction may drop from a high of about 0.925 immediately after glazing to 0.16 to 0.24 after deposition of foreign material from the atmosphere or after contact with other materials.

Thermal properties

Thermal expansivity and thermal conductivity are the two thermal properties of most importance to the designer or engineer.

TABLE 1—PROPERTIES OF COMMERCIAL GLASSES

Type	Principal Use	Coeff of Exp 10^7 per F (32-575 F)	Density, gm/cu cm	Refract. Index (Sod-D)	Electrical Properties				Young's Mod 10^{-6} psi
					Log_{10} Vol Res, ohm-cm		Diel Prop (1mc, 68F)		
					480 F	660 F	Pow Fact	Diel Con	
Silica Glass (Fused silica)	—	3	2.20	1.458	12.0	9.7	0.0002	3.78	10
96% Siiica Glass (7900)	—	4.5	2.18	1.458	9.7	8.1	0.0005	3.8	9.7
96% Silica Glass (7911)	—	4.5	2.18	1.458	11.7	9.6	0.0002	3.8	9.7
Soda-Lime	Window Sheet	47	2.46	1.510	6.5	5.2	0.004	7.0	10
Soda-Lime	Plate	48	to	to	to	to	to	to	10
Soda-Lime	Containers	47	2.49	1.520	7.0	5.8	0.011	7.6	10
Soda-Lime	Elect. Lamp Bulbs	51	2.47	1.512	6.4	5.1	0.009	7.2	9.8
Lead-Alkali Silicate	Electrical	50.5	2.85	1.539	8.9	7.0	0.0016	6.6	9.0
Lead-Alkali Silicate	High Lead	50.5	4.28	1.639	11.8	9.7	0.0009	9.5	7.6
Alumino-Borosilicate	Apparatus	27	2.36	1.49	6.9	5.6	0.010	5.6	—
Borosilicate	Low Expansion	18	2.23	1.474	8.1	6.6	0.0046	4.6	9.8
Borosilicate	Low Electrical Loss	18	2.13	1.469	11.2	9.1	0.0006	4.0	6.8
Borosilicate	Tungsten Seal	25.5	2.25	1.479	8.8	7.2	0.0033	4.9	—
Alumino-Silicate	—	23.5	2.53	1.534	11.4	9.4	0.0037	6.3	12.7

Source: Copyrighted material from revised new edition of *Glass Engineering Handbook*, by E. B. Shand, Corning Glass Works, published by McGraw-Hill Book Co., New York.

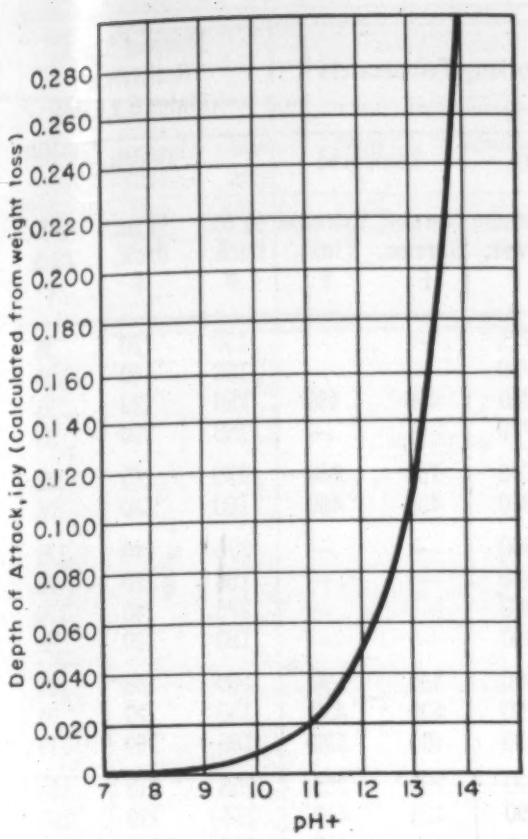


Fig 1—*Note rapid increase in rate of attack on a borosilicate glass with higher alkalinity of solution.*
(Corning Glass Works)

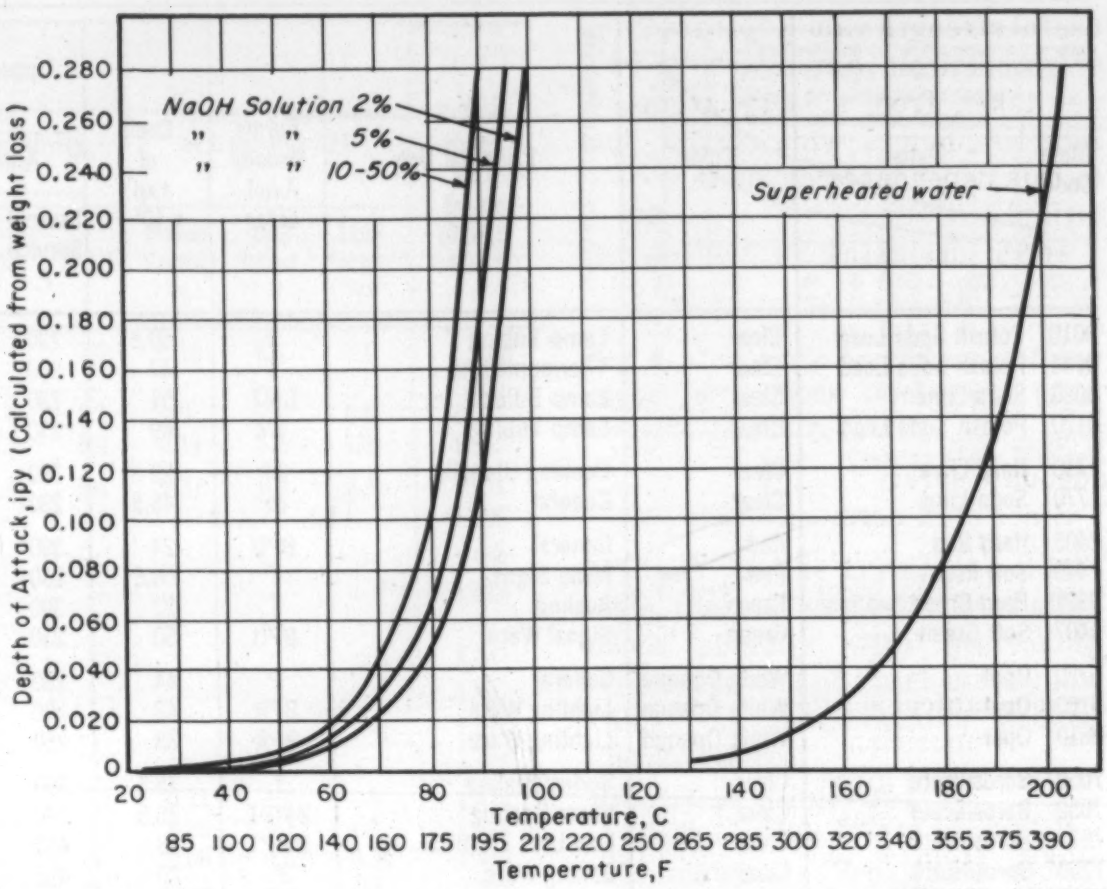


Fig 2—*Three curves at left show effect of increasing temperature from ambient to about 212 F on rate of attack on a borosilicate glass by three concentrations of sodium hydroxide solutions. At right, note sharp increase in rate of attack on borosilicate glass by water at temperatures above 300 F.*
(Corning Glass Works)

Thermal expansivity — The amount of expansion and contraction on exposure to high and low temperatures predicts the degree to which glass will resist thermal shock. It also dictates certain design limitations and limits the materials with which particular glasses may be used.

Expansion coefficients of most of the commercial soda-lime glasses range around 44 to 50 x 10^{-7} per °F. Coefficients can range from about 3.1 x 10^{-7} per °F for fused silica, to 4.2 x 10^{-7} per °F for 96% silica, to 27.7 x 10^{-7} per °F for borosilicates, to as high as 69 x 10^{-7} per °F for silica glasses to which other oxides have been added. Within this range, coefficients can be altered to suit design needs.

Stresses in glass set up by temperature-induced expansion and contraction can be in a steady state with constant temperature conditions, or transient with fluctuating temperatures. The latter condition defines the condition of thermal shock.

Steady state thermal stresses are imposed by the difference in temperature between one surface of glass and the other. The hotter surface expands and is under compression, putting the cooler side under tension. Since glass breaks only in tension, the magnitude of the tensile stresses on the cooler side is the factor limiting use of a glass to a certain temperature range. Magnitude of the tensile stress depends on the expansion coefficient, the modulus of elasticity and the temperature difference between the two glass faces.

Resistance to steady state

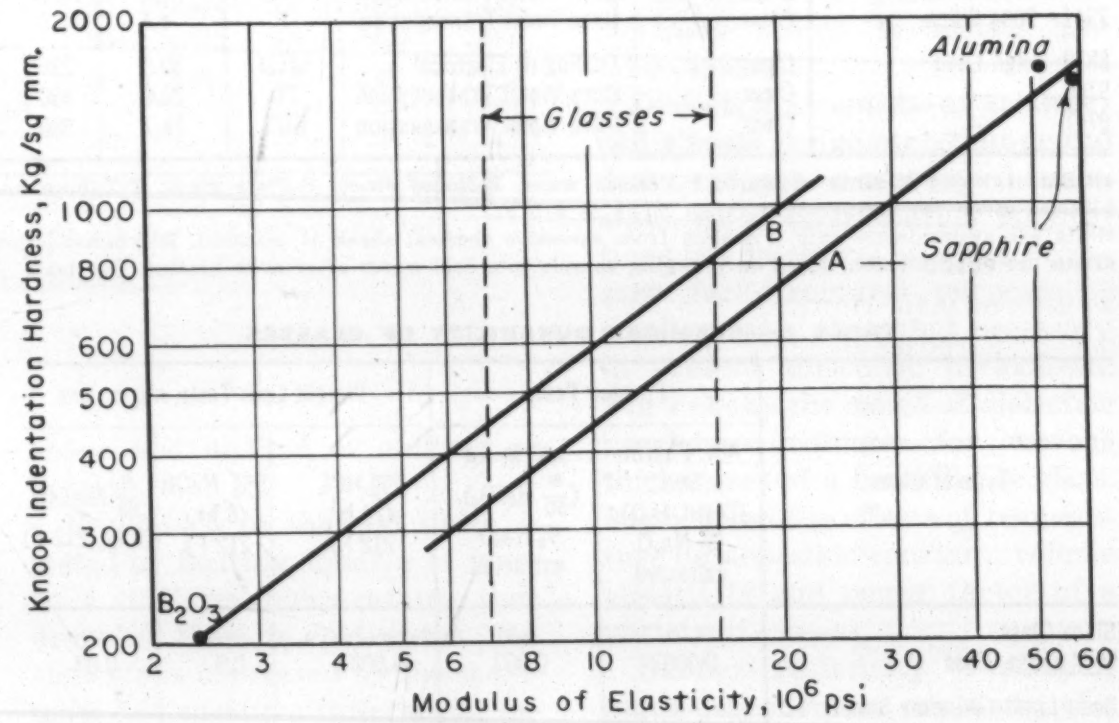


Fig 3—*Hardness of commercial glasses is plotted against modulus of elasticity.* (Copyrighted material from revised new edition of Glass Engineering Handbook, by E. B. Shand, Corning Glass Works, published by McGraw-Hill Book Co., New York)

TABLE 2—PROPERTIES OF

Glass Code	Type	Color	Principal Use	Forms Usually Available[a]	Coeff of Exp[b] x 10^7 F	Upper Working Temperature[c]				Thermal Shock Resistance[d] (Plates 6 x 6 in.)		
						Annealed		Tempered		Annealed		
						Normal Service, F	Extreme Limit, F	Normal Service, F	Extreme Limit, F	⅛ in. thick, F	¼ in. thick, F	½ in. thick, F
0010	Potash Soda Lead	Clear	Lamp Tubing	T	50.5	230	725	—	—	150	120	95
0041	Potash Soda Lead	Clear	Thermometers	T	47	230	750	—	—	160	140	105
0080	Soda Lime	Clear	Lamp Bulbs	BMT	51	230	860	430	480	150	120	95
0120	Potash Soda Lead	Clear	Lamp Tubing	TM	49	230	720	—	—	150	120	35
1710	Hard Lime	Clear	Cooking Utensils	BP	23	390	1200	750	840	275	240	170
1770	Soda Lime	Clear	General	BP	45.5	230	840	430	480	160	140	105
2405	Hard Red	Red	General	BPU	24	390	900	—	—	275	240	170
2475	Soft Red	Red	Neon Signs	T	50.5	230	820	—	—	150	120	95
3321	Hard Green Sealing	Green	Sealing	T	22	390	880	—	—	275	240	170
4407	Soft Green	Green	Signal Ware	BPU	50	230	860	—	—	150	120	95
6720	Opal	White Opaque	General	P	44	230	900	430	530	160	140	105
6750	Opal	White Opaque	Lighting Ware	BPR	48	230	790	430	430	150	120	95
6810	Opal	White Opaque	Lighting Ware	BPR	38	250	880	460	520	185	160	115
7050	Borosilicate	Clear	Series Sealing	T	25.5	390	820	255	255	255	210	160
7052	Borosilicate	Clear	Kovar Sealing	BMPT	25.5	390	790	410	410	255	210	160
7070	Borosilicate	Clear	Low Loss Electrical	BMPT	18	450	810	450	450	355	300	210
7250	Borosilicate	Clear	Baking Ware	P	20	450	860	500	500	320	265	195
7340	Borosilicate	Clear	Gage Glass	T	37	250	950	460	590	185	160	115
7720	Borosilicate	Clear	Electrical	BPT	20	450	860	500	500	320	265	195
7740	Borosilicate	Clear	General	BPSTU	18	450	910	500	550	355	300	210
7760	Borosilicate	Clear	Electrical	BP	19	450	840	480	480	320	265	195
7900	96% Silica	Clear	High Temp	BPTU	4.4	1470	1990	—	—	2280	1830	1380
7900	96% Silica (Sintered)	White Opaque	High Temp	M	4.4	1470	1990	—	—	2280	1830	1380
7910[g]	96% Silica	Clear	Ultra Violet Transmission	BTU	4.4	1470	1990	—	—	2280	1830	1380
7911[g]	96% Silica	Clear	Ultra Violet Transmission	T	4.4	1470	1990	—	—	2280	1830	1380
8870	High Lead	Clear	Sealing or Electrical	MTU	50.5	230	720	360	360	150	120	95
9700	—	Clear	Ultra Violet Transmission	TU	20.6	430	930	—	—	300	250	175
9741	—	Clear	Ultra Violet Transmission	BUT	21.7	390	730	—	—	300	250	175

[a]B-Blown ware; M-Sintered ware; P-Pressed ware; R-Rolled sheet; S-Plate glass; T-Tubing and rod; U-Radiant panels.
[b]Values given for temperature range of 32 to 575 F.
[c]Data are approximate only. Freedom from excessive thermal shock is assumed. Recommendations are based on mechanical considerations only.
[d]Data are approximate. Based on plunging sample into cold water after oven heating. See text.

TABLE 3—CHEMICAL DURABILITY OF GLASSES

Type of Glass	Powder Tests		Weight Loss Tests, mg/sq cm		
	Am. Pharm. Soc. (Distil. H_2O), % Na_2O extracted	ASTM—A ($\frac{N}{50}$ H_2SO_4), % Na_2O extracted	5% HCL (24 hr, 212 F)	5% NaOH (6 hr, 212 F)	$\frac{N}{50}$ Na_2CO_3 (6 hr, 212 F)
Silica Glass	—	—	—	—	—
96% Silica Glass	0.0003	0.002	0.0004	0.9	0.07
Soda-Lime—Window Sheet	—	—	—	—	—
Soda-Lime—Plate	0.03	—	—	0.8	0.18
Soda-Lime—Containers	0.05	0.03	0.05	0.8	1.5
Soda-Lime—Lamp Bulb	0.09	0.04	0.01	1.1	1.1
Lead Glass—Electrical	0.07	0.15	0.02	1.6	0.25
Lead Glass—High Lead	0.0006	—	disintegrated	3.6	0.81
Alumino-Borosilicate-Apparatus	—	0.005	—	1.0	0.13
Borosilicate—Low Expansion	0.0025	0.005	0.0045	1.4	0.12
Borosilicate—Low Elect. Loss	—	—	0.02	3.45	0.77
Borosilicate—Tungsten Seal	0.13	—	Completely leached	3.87	1.4
Alumino—Silicate	0.003	0.06	0.35	0.35	0.17
Special—Alkali-resistant	—	0.05	0.008	0.09	0.03

Source: Copyrighted material from revised new edition of *Glass Engineering Handbook*, by E. B. Shand, Corning Glass Works, published by McGraw-Hill Book Co., New York.

thermal stresses is expressed as that temperature difference — between one side of glass and the other—which produces a tensile stress of 1000 psi in the cooler surface. Thermal stress resistance of various glasses is given in Table 2. To determine steady state thermal stress resistance of glasses other than those listed, the following formula can be used:

$$\theta' = \frac{2000\ (1-\mu)}{E\alpha}$$

Where θ' = temperature differential between the two surfaces that will cause a tensile stress of 1000 psi on the cooler face.
μ = Poisson's ratio
E = modulus of elasticity
α = coefficient of linear thermal expansion

SOME TECHNICAL GLASSES

Thermal Stress Res.,[e] F	Impact Abra-sion Res[f]	Den-sity, gm/cc	Mod of Elast 10^{-6} psi	Log_{10} of Volume Resistivity			Dielectric Properties at 1 mc and 70 F			Refract Index Sod. D line (0.5893 microns)
				75 F	480 F	660 F	Power Factor, %	Diel Const.	Loss Factor, %	
66	—	2.85	9.0	17+	8.9	7.0	0.16	6.6	1.1	1.539
66	—	2.89	—	—	—	—	—	—	—	1.545
63	1.2	2.47	9.8	12.4	6.4	5.1	0.9	7.2	6.5	1.512
63	—	3.05	—	17+	10.1	8.0	0.16	6.6	1.1	1.560
84	2.0	2.53	12.7	17+	11.4	9.4	0.37	6.3	2.3	1.534
66	—	2.40	—	—	—	—	—	—	—	1.496
97	—	2.50	—	—	—	—	—	—	—	1.508
63	—	2.56	—	—	—	—	—	—	—	1.511
102	—	2.27	—	—	—	—	—	—	—	—
63	—	2.53	—	—	—	—	—	—	—	1.525
66	—	2.58	—	—	—	—	—	—	—	1.507
64	—	2.63	—	—	—	—	—	—	—	1.513
73	—	2.65	—	—	—	—	—	—	—	1.508
93	—	2.25	—	16.0	8.8	7.2	0.33	4.9	1.6	1.479
93	—	2.28	—	17.0	9.2	7.4	0.26	5.1	1.3	1.484
158	4.1	2.13	6.8	17+	11.2	9.1	0.06	4.0	0.24	1.469
109	3.2	2.24	—	15.0	8.2	6.7	0.28	4.7	1.3	1.475
68	—	2.43	11.5	16.0	8.5	6.9	—	—	—	1.506
113	3.2	2.35	9.5	16.0	8.8	7.2	0.27	4.7	1.3	1.487
118	3.1	2.23	9.8	15.0	8.1	6.6	0.46	4.6	2.1	1.474
124	—	2.23	9.1	17.0	9.4	7.7	0.18	4.5	0.79	1.473
392	3.5	2.18	9.7	17.0	9.7	8.1	0.05	3.8	0.19	1.458
392	3.5	2.18	9.7	17.0	9.7	8.1	0.05	3.8	0.19	1.458
392	3.5	2.18	9.7	17+	11.2	9.2	0.024	3.8	0.091	1.458
392	3.5	2.18	9.7	17+	11.7	9.6	0.019	3.8	0.072	1.458
72	0.6	4.28	7.6	17+	11.8	9.7	0.09	9.5	0.85	1.693
108	—	2.26	—	15.0	8.0	6.5	—	—	—	1.478
104	—	2.16	—	17+	9.4	7.6	—	—	—	—

[e]Resistance is expressed at the temperature differential between two surfaces of a tube or constrained plate that causes a tensile stress of 1000 psi on cooler surface. See text.
[f]Data show relative resistance to sand blasting.
[g]Electrical properties measured on lamp worked specimens.
Source: Corning Glass Works, Bulletin B-8.

Transient thermal stresses are introduced when glass undergoes a change of temperature. If a hot piece of glass is exposed to cold air, the surface is chilled and tensile stresses are set up which are resisted by compressive stresses in the center of the glass. If a cool piece of glass is exposed to high temperatures, the outer layers are heated and compressive stresses are set up which are resisted by tensile stresses in the cooler center. Since glass fails only under tension and usually at a surface, temporary stresses from sudden cooling are more damaging than those from heating. Transient thermal stresses increase directly with glass thickness and expansion coefficient, and depend on the shape and method of chilling or heating.

Resistance to thermal shock is tested by heating squares of glass to a uniform temperature, then dropping them in cold water. Resistance is expressed by the maximum temperature differential between glass and water at which no breakage occurs. Thermal shock resistance of various glasses is given in Table 2.

Thermal conductivity—Thermal conductivity values for glasses at room temperature range from 4.6 to 8.4 Btu/sq ft/hr/°F/in., with most common compositions at about 8.1 Btu/sq ft/hr/°F/in. Conductivity increases with increasing temperature. At a mean temperature of 400 F, values are 20 to 25% greater. Unlike crystalline materials, thermal conductivity of glass drops steadily with decreasing temperatures and reaches very low values at temperatures around absolute zero.

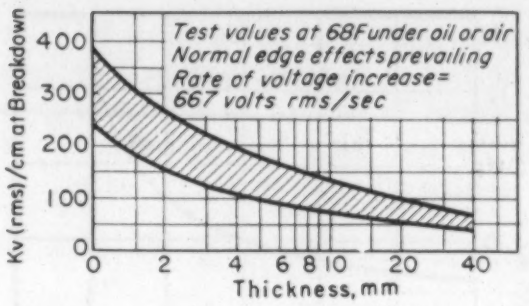


***Fig 4**—Dielectric breakdown voltage range for various thicknesses of a borosilicate glass.*
(Corning Glass Works)

Electrical properties

Glass is a commonly used dielectric material (See Table 4). It has high dielectric strength, high volume and surface resistivity, low power and loss factor and is nontracking. These properties are enhanced from the design standpoint by the ability of glass to be hermetically sealed to metals and other materials.

Dielectric strengths of commercial glasses are so high that actual data need not be considered in design. In most insulation applications the thickness of glass necessary for structural purposes is much greater than that necessary to prevent dielectric breakdown. Fig 4 shows the range of dielectric breakdown voltages for various thicknesses of a borosilicate glass. Fig 5 shows the effects of temperature on dielectric constant, volume resistivity and power factor of a variety of glasses.

Surface resistivity of glass is more dependent on contamination of the surface than on composition (See Fig 6). A film of moisture, the presence of dirt, or dissolved gasses in the moisture film seriously reduces resistivity. Surfaces can be protected effectively by liquid silicone coatings, soluble waxes, stannous chloride, and various lubricating materials.

Optical properties

There is a great deal of information available on the optical properties of glass. It is beyond

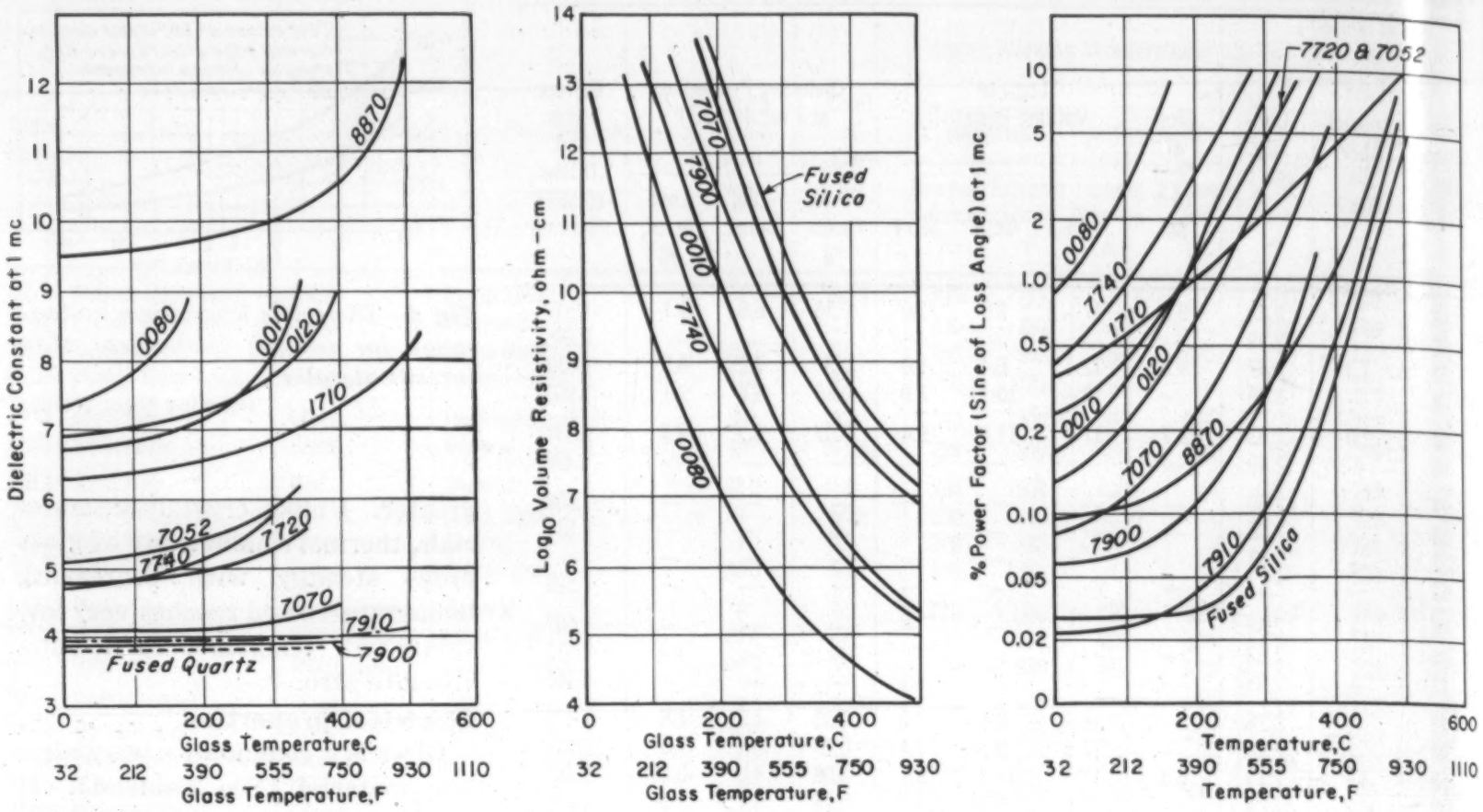


Fig 5—*Effect of temperature on dielectric constant, volume resistivity and power factor of various glasses. To determine types of glasses referred to by code numbers see Table 2.* (Corning Glass Works)

the scope of this article to go into detail on this highly complex and specialized field. Remarks here are limited to general light transmission and absorption characteristics.

Light transmission of glass can be varied as desired. Common lime glasses transmit about 85 to 95% of visible light, while the best optical glass, lead glass, transmits about 99%. Glass can be formulated to absorb almost any desired part of the visible spectrum, and much of the regions above and below it. By formulating to selectively absorb certain bands of the visible spectrum, glasses of a wide variety of color can be obtained.

In the invisible range of the spectrum, glasses can be formulated to transmit a high percentage of infrared rays for heat lamps. On the other end of the spectrum, glasses can be formulated to transmit large percentages of ultra violet light for applications such as germicidal bulbs, or to absorb large percentages of ultra violet light for applications

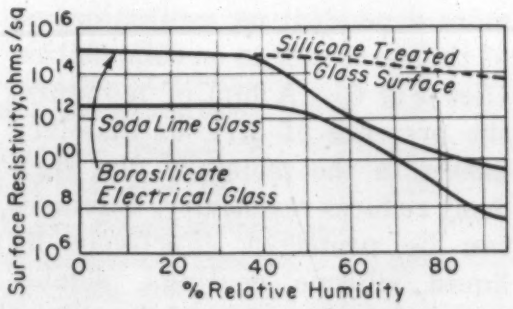


Fig 6—*Note sharp decrease in surface resistivity of glass exposed to relative humidity above about 40%, as compared with that of glass surface protected with a silicone treatment.* (Corning Glass Works)

TABLE 4—COMPARISON OF ELECTRICAL PROPERTIES OF INSULATING MATERIALS
(Room Temperature)

Material	Intrinsic Dielectric Strength[a]		Diel Con	Vol Resist ohm-cm
	Thickness, mm	Kv/cm		
Cellulose Acetate	0.025–0.12	2300[b]	5.5	10^{12}
Glass				
Borosilicate (7740)	0.10	4800[c]	4.8	10^{16}
Soda Lime	0.10	4500[c]	7.0	10^{12}
Soda Lead	0.10	3100[c]	8.2	10^{14}
Mica, Muscovite Clear Ruby	0.020–0.10	3000–8200[b]	7.3	10^{17}
Phenolic Resin	0.012–0.04	2600–3300[b]	7.5	10^{11}
Porcelain, Electrical	—	380[b]	4.4–6.8	10^{14}
Silica, Fused	—	5000[c]	3.5	10^{18}
Rubber, Hard	0.10–0.30	2150[b]	2.8	10^{13}
Porcelain, Steatite—Low Loss	—	500[b]	6.0–6.5	10^{15}

[a]Intrinsic dielectric strength can be realized only under special test conditions and is very much higher than the working dielectric strength attainable in ordinary service. These data are listed for purposes of comparison.
[b]S. Whitehead, *World Power*, p 72, Sept 1936.
[c]P. H. Moon and A. S. Norcross. *Trans. A.I.E.E.* 49, 755, (1930).
Source: Phillips, C. J., *Glass, the Miracle Maker*, Pitman Publishing Co.

such as protective goggles or store display windows.

Radiation effects

Knowledge of the effects of high energy radiation on glass is far from complete. Glasses do tend to discolor, and some types such as the nonsilicate, which show little fluorescence ordinarily, fluoresce brightly when exposed to ultra violet light after radiation. Absorption of high energy radiation can be produced by use of heavy concentrations of lead and by some other types of metallic oxides.

Design Forms of Glass

As a standard engineering material available from stock, glass is produced in four basic forms: *flat, container, rod* and *tubing.* For purposes of discussion, the fifth basic form in which glass is available will be called *custom formed.* This category includes glass forms produced by pressing, blowing or a combination of the two to serve specific product or design needs. For example, such products as light bulbs and television tubes are considered here to be custom formed products. In addition to these basic forms, there are several specialty glasses, such as foamed, ribbon, and photosensitive glass. Glass fibers are used in increasing quantities for insulation, cloth and mat, and as a reinforcing material for plastics. However, from the engineering standpoint it is usually dealt with more as a textile than as glass, and thus it will not be included in this article.

Flat glass

Flat glass is formed by drawing vertically or rolling horizontally, depending on the type being produced. It is manufactured in a variety of types to meet specific end uses.

Polished plate is produced from soda-lime glass by rolling horizontally and grinding and polishing on both sides to conform with Federal Spec DD-G-451a. It is available clear with light transmission of about 88% (¼-in. thickness), or colored to absorb heat glare. Formulations can be altered to transmit as little as 25-40% ultraviolet while still transmitting 70-75% of total visible solar light. Polished plate is generally available in thicknesses ranging from ⅛ to 1¼ in. Sizes vary between manufacturers.

Though properties such as modulus of rupture and compressive strength vary widely, typical properties of polished plate glass, as determined on standard production lots, are approximately as follows:

Modulus of rupture, psi cross section	6500
Compression strength, (1-in. cube), psi	36,000
Modulus of elasticity, psi	10×10^6
Coefficient of expansion, per F	44.5×10^{-7}
Thermal endurance (2 x 2 x 7/32 in. sq), differential F	100

Polished plate is used in applications such as table and counter tops, cold storage windows, signs, clock dials, picture frames, lighting fixtures, locomotive headlights, and aquatic tanks.

Tempered plate is formed by heat treating plate glass to form a surface skin that is in compression while the core area is in tension. While retaining the same appearance, clarity, hardness and coefficient of expansion as the glass from which it is made, tempered glass is three to five times stronger than plate glass in sustaining loads and resisting fracture due to strain. It is about three to five times more resistant to impact shock from blunt objects and about four times more resistant to thermal shock. Its flexibility under stress is the same as that of the original glass, but it may be flexed from four to five times farther than normal glass before it breaks. Upon breaking, tempered glass disintegrates into small granular fragments. All cutting and machining operations must be done before the glass is heat treated.

For some applications only partial tempering is used to obtain strength properties intermediate between those of annealed and tempered glass. This partially tempered glass is called *heat strengthened glass.* Tempered or heat strengthened glasses are used for such applications as airport control towers, swinging doors, television implosion plates, hospital glazing, military glazing, steam gage guards, oven glazing, kick plates, safety mirrors, engine test room windows, refrigerator shelves, partitions and doors, and explosion resistant mirrors.

X-ray lead plate is a highly leaded specialty glass regularly sold in the form of ground and polished plate. It is available in several qualities, such as protective, fluoroscopic and photographic. It is generally ¼ in. thick and in service should be protected by a sheet of conventional plate glass. It has an exceptionally high index of refraction of 1.7608. Typical modulus of rupture values would range around 5000 psi cross section, though they may vary widely. Some of its other properties are as follows:

Modulus of elasticity, psi	8×10^6
Light transmission (¼ in. thick), % min:	
Total visible white light	80
Total radiant energy	80
Total solar ultra violet	15
Ultra violet (wave lengths of 0.350 and shorter)	00
Solar infrared	82

X-ray lead plate is used for screens for x-ray work, all types of fluoroscope machines, experimental work and novelty articles.

Window, picture and heavy sheet is manufactured by drawing glass horizontally or vertically and is untouched by rolls or foreign substances until it has cooled sufficiently to be beyond injury. The material has an unusually brilliant, reflective and unmarred surface finish on both sides. It is made of soda-lime glass, fire-

polished and annealed. Grades produced today show only slight waviness and are satisfactory for most architectural glazing applications. Physical, mechanical and light transmission properties of these types of glass are substantially the same as those of polished plate. In addition to architectural applications, these grades of glass are used for such articles as picture frames, table tops, dial covers, shelves, signs and kitchen cabinets.

Special flat glass

Special flat glasses include a variety of single sheet glass produced to meet specific purposes.

Heat resisting glass, usually of the borosilicate type, is produced in quantity for heat protection shields, sight glasses in ovens and furnaces and electrical insulators. The borosilicates can be heat strengthened or tempered, increasing their strength up to four-fold.

Ultra violet conductive glasses are usually high-silica glasses that conduct high percentages of solar ultra violet radiation. Common window glass transmits only about 10% of ultra violet radiation. This type of conductive glass is used for germicidal lamps, hospital sunporches, greenhouses, etc.

Polarizing glass consists of sheet glass coated with an organic crystalline chemical that polarizes the light transmitted. It is used for a variety of anti-glare applications.

Figured glass has an ornamental figure rolled into the surface while it is semi molten. Any of a variety of basic patterns are available. Major use is to diffuse light and to achieve obscurity.

Wire glass, a type of safety glass, is made by embedding wire mesh in the molten glass. It is usually made with ordinary soda-lime sheet glass, but sometimes a heat-absorbing glass is used to reduce the amount of transmitted solar heat. Wire mesh minimizes the danger of fragmentation occurring during breakage. It is used for skylights, shields, air raid precautionary shielding and greenhouse glazing.

Laminated glasses

Laminated glasses are produced in a variety of types.

Safety glass consists of two layers of plate or sheet glass bonded by a vinyl type plastic, usually polyvinyl butyral. By using any of several types of glass, as well as altering the type or color of the interlayer, a relatively wide range of properties is available.

Safety sheet consists of sheet glass and clear plastic. It is the least expensive grade.

Heat absorbing laminated sheet is made with heat absorbing sheet glass which reduces the amount of solar heat transmitted.

Tempered laminated glass is made with two or more layers of heat-strengthened glass. All cutting or machining operations must be carried out before the glass is heat treated and laminated.

Safety plate consists of plate glass laminated in the same manner as safety sheet glass. Most automobile glazing, especially windshields, where optical requirements are high, consists of safety plate. Tinted safety plate makes use of heat absorbing plate glass and the colorability of the vinyl interlayer to introduce tints in controlled areas of the glass.

Bullet-resistant glass consists of several laminations of plate glass, usually three, and can be produced in thicknesses up to 3 in. It is designed for use where special protection is necessary, usually protection against firearms. It is used in crane cab windows, speedboat shields, military cars and aircraft, and toll booths.

Double glass for thermal insulation consists of two layers of glass bonded to a spacer. The space between the two layers is then dehydrated to remove moisture. The structure effectively reduces conductance of heat through the glass.

Design of flat glass products

The forming and fabrication of

Joining glass

Due to space limitations the discussion here is limited to those methods which produce a hermetic seal. Mechanical joining methods are excluded.

Glass-to-glass seals can be made by heating the glass edges and joining while in the molten state. The two glasses must have similar expansion characteristics so that high stresses are not set up during cooling of the sealed joint. Glasses of widely differing expansion coefficients can be joined by graded seals. Graded seals consist of a number of segments of glass that have been welded together. Each segment in progression has a slightly different expansivity. Together the segments form a zone of gradual transition between high and low expansion coefficients. Graded seals are also used to join glasses to metals where expansivities are widely dissimilar.

Glass-to-metal hermetic seals can be formed between a variety of glasses and a number of metals, as can be seen in the table. Again, expansion coefficients should be similar. There are several requirements which limit the metals that can be joined to glass. They are: 1) thermal expansion of the metal must be uniform over temperatures ranging from below room temperature to above the annealing point of the glass; 2) the metal must be stable during sealing, i.e., it must not soften or burn at sealing temperatures; 3) adhesion between the metal and its oxide must be good; and 4) amount of gas given off by the metal at sealing temperatures must be extremely low.

The mechanism of glass-metal seals is not completely understood. But it is known that it depends to a degree on the characteristic of the oxide film which forms on metals when they are heated. The oxide film should be relatively thin, to eliminate danger of flaking from the metal surface, and must be nonporous if a hermetic seal is desired. When the glass and metal surfaces are heated, temperatures must be high enough so that the glass becomes molten and makes intimate contact with the metal

GLASS-METAL COMBINATIONS FOR SEALS[a]

Metal or Alloy	Trade Name or Type	Thermal Cond Btu/sq ft/hr/F/in.	Elect Res at 68F, ohm-cm x 10^6	Matching Glass		Remarks
				Corning	Kimble	
Cold-Rolled Steel; SAE-1010, AISI-C 1010	Other grades of soft steel or iron also used	313.5	18	1990, 1991		Tends to oxidize excessively. Plating with Cu, Cr or Ag often used to prevent this. External rings of iron are frequently sealed to Pt-sealing glasses
17% Chromium-Iron	Allegheny Telemet					Used in metal TV picture tubes as a ring seal outside a glass plate of lower expansion, putting glass in compression
28% Chromium-Iron	Allegheny Sealmet 1, Ascaloy 446, Carpenter 27	174.2	72	9012	K-51	Used in TV tubes. Pt-sealing glasses can also be used under certain conditions and types of seals. Alloy should be preoxydized in wet H_2 gas
Platinum		478.9	10.6	0010,	R-5, R-6,	Now used mainly for scientific apparatus. Pre-oxidizing unnecessary
Composite Material: Core 42 Ni, 58% Fe. Sheath: Cu	Dumet	116.1	4 to 6	0080, 0120, 7570,	KG-12	Copper sheath bonded to core. Surface usually coated with borax to reduce oxidization. Expansion: Radial—50 x 10^{-7}/F. Axial—35 x 10^{-7}/F. Wire size usually limited to 0.020 in. dia
Nickel-Chromium-Iron: 42 Ni, 6 Cr, 52% Fe	Sylvania No. 4, Allegheny Sealmet HC-4, Carpenter 426	92.9	34	8160, 9010		Matches Pt-sealing glasses. Relatively large seals can be made between this alloy and suitable glasses. Pretreatment in H_2 atmosphere furnace essential
Nickel-Cobalt-Iron: 28 Ni, 18 Co, 53% Fe	Kovar, Fernico, Rodar	133.5	47	7040, 7050, 7052, 7055, 8830	K-650, K-704, K-705	Low-expansion sealing alloy. Should be annealed after cold-working and pretreated in H_2 atmosphere furnace
Molybdenum		1016.1	5.7	7040, 7052		Metal rods usually ground and sometimes polished. Surfaces should be cleaned in fused nitrite, and not over oxidized
Tungsten		1103.1	5.5	3320, 7050, 7720, 8830	K-772	Same as for molybdenum
Copper	OFHC Grade (Oxygen-free high-conductivity)	2670.8	1.75	Most Glasses		Copper-glass seals are made with Housekeeper technique with thin metal sections. Care must be taken to prevent over-oxidation of copper

[a]Physical properties of metals and alloys from Monack and Partridge

Source: Copyrighted material from the revised new edition of *Glass Engineering Handbook*, by E. B. Shand, Corning Glass Works, published by McGraw-Hill Book Co., New York.

oxide film. The oxide is diffused or dissolved to some degree in the glass.

Metallized glass can be used in various ways, with the metallized surface serving either a decorative or useful function in itself, or as a base to which metal parts can be soldered. The metallized surface can be produced by spraying or by firing from a paste. Metals which can be sprayed on glass include copper, brass, silver, aluminum or zinc. The bond is primarily mechanical in nature.

Coatings of silver or other noble metals can be fired on glass at high temperatures from a paste form. The coatings can then be prepared for soldering by applying a final coat of tin or tin-lead solder. Low melting point solders such as 50-50 tin-lead, silver lead or bismuth are recommended.

Metal parts soldered to glass should be thin (maximum about 0.031 in.) and should be proportioned so that differential expansion can be taken up by flexing of the metal. Stresses caused by soldering should be as nearly normal to the glass surface as possibe. When tangential stresses occur, they can be minimized by reducing the area of metal-glass contact and by keeping the soldered metal ⅛ to 3/16 in. within the metallized area. Metal rings, caps and diaphragms should be designed so that stresses in the glasses are compressive rather than tensile.

flat glass is still largely an art rather than a science. What cannot be done today may be done tomorrow. Consequently there are few design criteria which can be stated definitely. It should be useful, however, to point out some of the basic operations which can be carried out on flat glass.

Flat glass can be bent in a variety of cylindrical, spherical and compound curvatures. Specific questions as to feasibility of design should be directed to the glass manufacturer.

Glass can be acid etched with hydrofluoric acid to produce frosted or semi-polished appearance. Shapes can be produced by sand blasting through a patterned resistant material which is bonded to the glass and removed after blasting. Shading can be accomplished by successively removing different portions of the resist.

Edges of flat glass can be ground and polished to produce beveled, seamed, swiped, flat, half-round and pencil edges. Engraving and mitering can be done with narrow face, power driven grinding wheels to produce intricate designs.

Container ware

When glass is selected for a container material, it is usually because of one, some, or all of the following characteristics, the combination of which is unique to glass: chemical inertness, transparency, odorlessness, tastelessness, high puncture strength, high internal pressure strength, high temperature limit, inertness to ultra violet rays, impermeability to moisture, impermeability to gases, effectiveness of seal, ease of opening, versatility of shape.

Glass container ware is formed almost exclusively on automatic machinery, and almost all containers are of soda-lime glass. Their properties are similar to those of plate and sheet glass. The purpose of modifications of container glass formulations is usually to improve processing characteristics of the glass rather than to alter end properties.

Bottles and jars are formed by vacuum-and-blow, press-and-blow, and blow-and-blow techniques. A quantity of molten glass is initially formed in the parison mold to suit the final shape of the container. The glass is then transferred by the neck to a mold where the body of the jar or bottle is blown. Forming of such containers is usually done rapidly on multi-station machines.

Though the majority of glass containers are of clear glass, colors such as amber, green or opal white can be produced for identification, protection from ultra violet light, quality control instrumentation, or aesthetic reasons.

Little can be said about the design of containers. Container manufacturers do most of the actual designing, working to general aesthetic or functional specifications of the customer. The limitations on shape are those common to all glass design. The shape which is most feasible to produce is that which most closely resembles normal flow lines of molten glass. Sharp corners are stress concentrators and must be avoided. For more detailed design recommendations, see section on custom-formed glass.

Rod and tubing

Glass rod is generally available in sizes ranging from ¼ to 1 in. in diameter. It is used primarily for reforming into beads, jewel bearings and novelty glassware. Tubing is available in a variety of sizes and wall thicknesses. Diameters range from less than ⅛ to over 6 in. in standard lengths of 48 or 60 in., depending on diameter. Special lengths are available up to 12 ft, or in some cases 20 ft.

Tubing is generally available from stock and can be reworked by heating and forming into a variety of shapes, including test tubes, small beakers, vials, syringe bodies, tapered tube flow meters, coils, laboratory condensers and fuses. Precision tubing, which has been re-formed to highly precise dimensions, is also available from some suppliers. Dimensions of this tubing can be held to tolerances of ±0.001 to ±0.0001 in. per in.

Tubing is normally supplied with one of three end finishes: 1) *Cut* ends are made by scoring and breaking the tubing. Surface is neat and relatively square. This type of finish is adequate when tubing is to be reworked. 2) *Fire polished* ends are rounded and are recommended when tubing is to be used as purchased. Ends have good mechanical strength and chip resistance. 3) Ends are *ground* when flatness and squareness are critical.

Where service conditions are unusually severe, special tubing or pipe, made of Pyrex glass, is available. Pyrex is a trade name for a particular type of borosilicate glass with a very low alkali content. Pyrex pipe has exceptional resistance to mechanical and thermal shock, high chemical resistance and smooth interior surfaces. The pipe, depending on size, is recommended for working pressures up to 50 psi, 200 F max sudden temperature differential, and 450 F max operating temperatures. Linear coefficient of expansion is only 18 x 10^{-7}. It is available in diameters ranging from 1 to 6 in., and in stock lengths of ½ to 10 ft.

Custom formed glass

So-called custom formed glass should be considered by the engineer or designer who needs the properties of a type of glass in a shape other than one which is mass produced in commercial form.

Blown ware is formed by collecting molten glass on the end of a blow iron and blowing a blank which is then inserted in a mold and blown out to the final shape. Blow molds for glass are of three general types: 1) Paste molds are used for circular shapes. Mold is lined with a carbonaceous paste which is kept wet during blowing to maintain a cushion of steam between the glass and the mold surface. Glass is rotated during blowing, producing a superior gloss or finish, 2) Hot iron molds are used for non-circular shapes

where quantity does not justify press-and-blow machine molding, or where parts are too large to be handled on machines. Hot iron molds have no inside coating; glass is blown directly against the mold. 3) Press-and-blow iron molds are used to produce glassware by machine at high production rates. In this method the glob of glass is placed in the bottom of a parison mold. The neck of the shape is then pressed and the part transferred to a blow mold, where the blank is blown out to finished shape. This method is used for forming bottles and jars in container ware production.

Recommendations for designing blown glassware, from the standpoint of shape, dimensions and quantity, are given in an accompanying box. There are several general considerations outlined by Corning Glass which should be kept in mind when designing.

1. For lowest cost and for large quantities, parts should be designed for paste mold or press-and-blow manufacture.

2. A pear shaped piece is ideally suited to blowing since the normal distribution of glass in the hot blank corresponds to that needed for the finished part. An inverted cone shape is undesirable since the glass distribution required is almost exactly the opposite of that in the naturally formed hot blank.

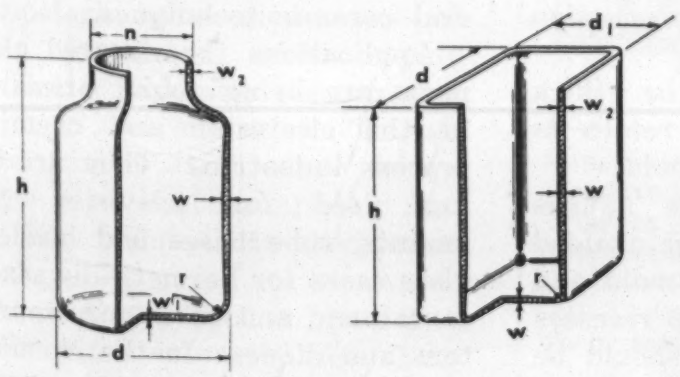
3. A blank with a long thin neck is difficult to handle during the blowing operation. If required in quantity, bulk sections would probably be machine made and the necks sealed on in a second operation.

4. Wall thickness cannot be positively controlled. It depends on glass distribution in the blank and on the shape into which it is blown. Sharp changes in wall contour are undesirable because glass cannot be blown out fully without sacrificing wall thickness at the enlarged section.

5. In hot iron ware a circular section at the cut-off point permits a flame burn-off which is

BLOWN GLASSWARE DESIGN

Method of Manufacture		Size Group	Smallest Desirable Production Run, Pieces	d Dia or Width (Usual Range) in.	h Height (Usual Range) in.	h:d Height vs Dia Max Ratio	d:d Length vs Width, Max Ratio	w Normal Median Wall Thickness, in.		Wall Thick Variation, Piece to Piece,[a] %±	d:n Max Ratio Body Dia to Neck	r Min Corner Radius	Weight[b]
								Light Wall Ware	Heavy Wall Ware				
Paste Mold	Hand	Small	1000	1–2	3–8	10:1	—	0.060	0.100	33	3:1	d/5	8 oz
		Medium	350	2–7	8–18	6:1	—	0.075	0.140	33	4:1	d/7	10 lb
		Large	50	7–20	12–30	3:1	—	0.090	0.250	50	5:1	d/10	35 lb
	Machine	Small	100,000	1–3	3–5	3:1	—	0.060	0.100	33	3:1	d/5	4 oz
		Medium	75,000	3–5	4–6	2:1	—	0.070	0.100	33	3:1	d/5	8 oz
		Large	75,000	5–6½	5–10	1½:1	—	0.070	0.090	33	2¼:1	d/5	1 lb
Hot Iron	Hand	Small	2000	1–3	3–8	10:1	2½:1	0.060	0.100	33	3:1	d/5	8 oz
		Medium	700	3–8	8–18	6:1	1½:1	0.075	0.140	33	4:1	d/7	10 lb
		Large	50	8–20	12–30	3:1	1:1	0.090	0.250	50	5:1	d/10	35 lb
Press and Blow	Machine	Small	150,000	¾–2	1–3	3:1	2:1	0.060	0.100	25	3:1	⅛ in.	3 oz
		Medium	100,000	2–4	3–6	3½:1	2:1	0.075	0.120	25	4½:1	¼ in.	1 lb
		Large	50,000	4–6½	6–12	3:1	2:1	0.120	0.180	25	6:1	⅜ in.	3½ lb

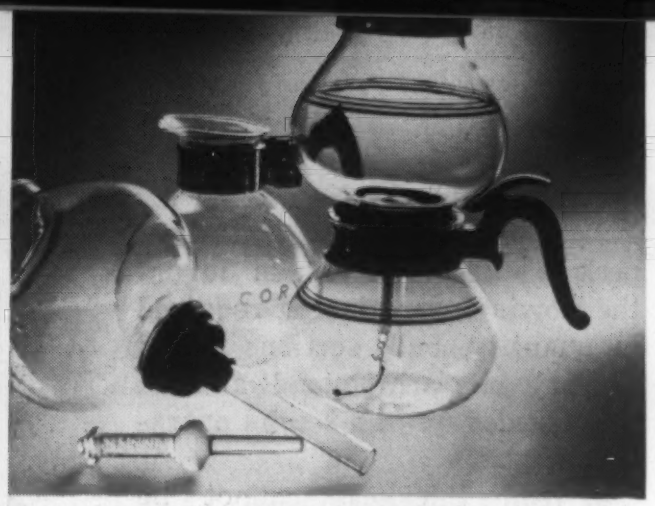


Normal Tolerances on Outside Dimensions

Height Tolerance		d or d_1, in.	Diameter or Width Tolerance,[c] in. ±		Max Out of Round,[d] Major Axis Less Minor Axis
h, in.	Tolerance, in.		Paste Mold Ware	Iron Mold Ware	
1–3	±1/16	1–3	1/32	1/32	0.02 x d
3–6	±1/16	3–6	3/64	3/64	0.02 x d
6–9	±1/16	6–9	1/16	1/16	0.0175 x d
9–12	±1/16	9–12	3/32	1/16	0.0175 x d
12–20	±⅛	12–20	⅛	1/16	0.0175 x d

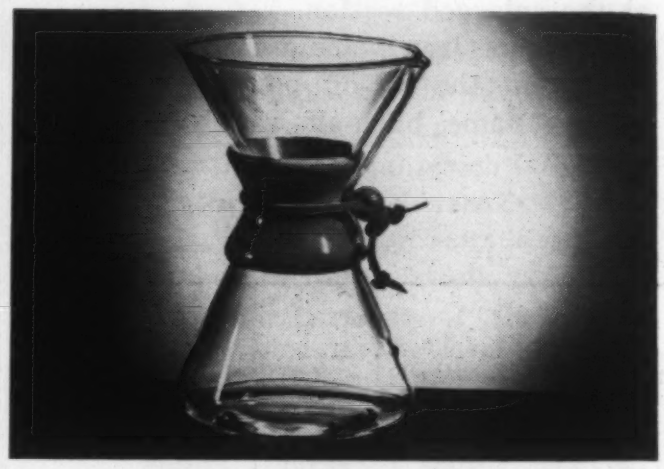
[a] In any one piece: $w_1 = 1.5w$, and $w_2 = 1.33w$.
[b] Weight based on density of commercial glasses.
[c] Tolerance on diameter of circular pieces is on mean diameter and does not include out-of-round.
[d] This is a maximum allowable degree of ellipticity in circular articles, e. g., maximum differential between largest and smallest diameters at one place on a 10 in. cylinder is 10x0.0175 or 0.175 in. out-of-round.

Source: Corning Glass Works, Bulletin B-84.

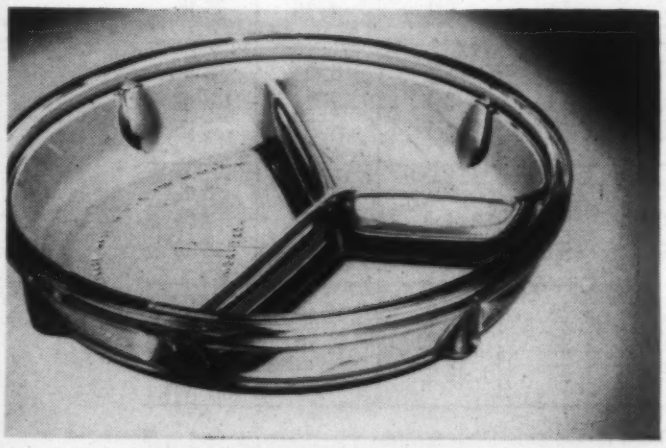


Photos from Corning Glass Works

Pastemolds and font molds *are used to form such shapes as these. The strainer in foreground is formed in font mold.*

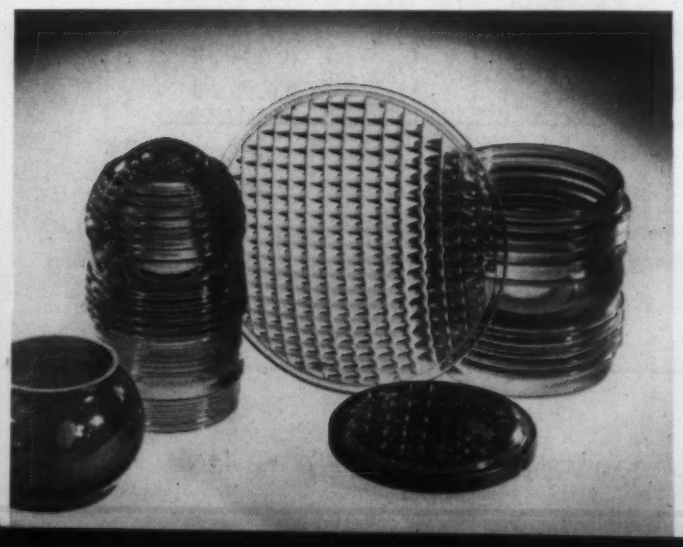


Hot iron molds *are used to form this type of shape.*



Block molds *are used to press simple shapes such as this dish.*

Split molds *are used to press round pieces shown, while one-piece molds are used to form flat lenses.*



considerably cheaper than other methods.

Pressed ware is formed by loading a mold with a glob of glass, closing the mold opening and then pressing the glass out to fill the mold with a plunger. There are three types of molds: 1) Block molds are used for forming simple tapered pieces with no reentrant contours and no vertical seams. Since the mold is in one piece it is the cheapest to use and easiest to maintain. Since there is no provision for glass overflow, and the plunger continues until the glass completely fills the mold, weight and section thickness depend entirey on the size of the glass charge. 2) Split molds are used for forming parts with reentrant contours, requiring the mold to be opened before part can be removed. Parts have a vertical as well as a ring line seam. Cost is usually higher than that of block mold pressed parts. As in block mold pressing, weight and section thickness is dependent on size of glass charge. 3) Font molds are used for forming parts of such shape that glass cannot be placed directly into mold cavity, e.g., utensil handles, etc. Glass is placed in a font and plunger forces it into the mold cavity. Font mold pressware is not subject to weight and thickness variations since the font forms a reservoir for surplus glass.

Several general design factors are suggested by Corning to aid in obtaining desirable shapes.

1. Drafts and corner radii should be generous to simplify molding and reduce production costs.

2. Sections should be thick enough for the glass to retain its fluidity as it fills the mold.

3. Unnecessarily wide flanges around the top should be avoided as they are difficult to mold and are usually weak. Sharp recesses in the bottom or wall should be avoided if shallow grooves or rounded ridges will serve the purpose. Change in section thickness should be as gradual as possible.

4. Due to cost considerations, parts should be designed for block molding whenever possible. Consequently, lettering or reentrant contours should be located in the bottom of the piece rather than in the side.

5. Straight parting lines are desirable. In many cases this can be accomplished by incorporating the parting line entirely in the mold ring. Interrupted parting lines can be produced, but are not recommended.

6. Center ridges in the bottom of parts, involving recesses in the plunger, should be as low and thick as possible to allow the hot glass to fill them readily.

Specialty glasses

Sintered glass parts can be produced by techniques closely resembling powder metallurgy. Powdered glass is mixed with a binder, molded and sintered to form a vacuum-tight monolithic structure with a density of about 98% that of an equal volume of the parent glass.

Pressed and sintered parts can be made from most types of glass. Physical and electrical characteristics are approximately the same as those of the parent glass, though mechanical strength is slightly less.

Design requirements are normally those of a straight press-type dry molding. Irregular surfaces should be perpendicular to the press stroke and axes of holes should be parallel to it. Undercuts and reentrants should be avoided and generous radii allowed between heavy and light sections. Shapes can also be slip cast by a method similar to general ceramic techniques.

Applications for sintered glass parts are being found primarily in the electronic and chemical process industries. They are being used for television gun mounts, tube bases and headers, glass cases for hermetically sealed containers, and cases for transistors and diodes. In the chemical industry the material is being used for pipe line filters, bubble caps and perforated plates. (For further information on sintered glass see M&M, Oct '54, p 94.)

Cellular or foamed glass is

formed by heating pulverized glass in a gasifying substance such as carbon. When the glass becomes molten, the gas expands and forms cells which are trapped when the glass solidifies, forming a material with an apparent density of 10 lb per cu ft. The material, available in the form of cut shapes, is primarily used for insulation. It can also be used for buoyancy applications. It has a thermal conductivity (K) value at 50 F of about 0.033 Btu/hr/sq ft/°F/ft. It can be used at operating temperatures of −350 to 800 F. Other typical properties of cellular glass are as follows:

Specific gravity, g/cc	0.16
Coefficient of expansion, per °F	22×10^{-7}
Specific heat, Btu per lb	0.20
Moisture absorption, lb/sq ft of nominal surface area	0.03
Modulus of elasticity, psi	180,000
Strength, psi:	
Compressive	140
Flexural	100
Shear	64
Tensile	84

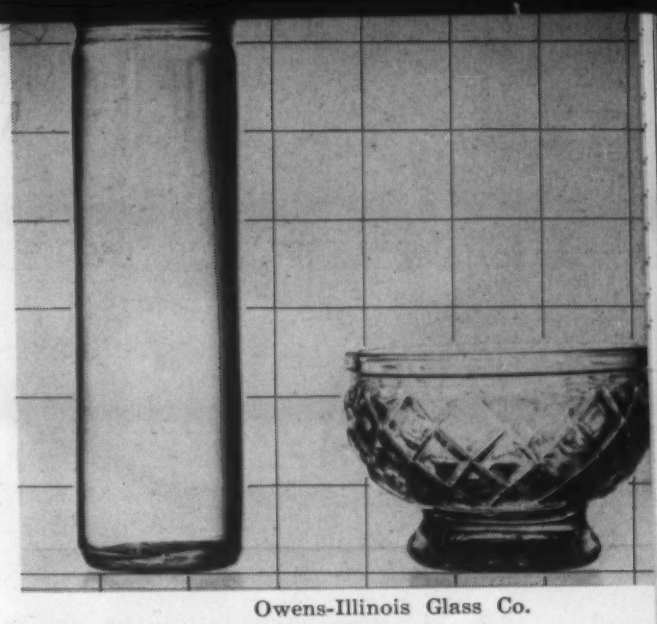
Cellular glass is available as blocks, curved segments, flat segments, shaped covering for standard pipe, and as coverings for valves and standard fittings. The material can be cut and shaped in the field with common tools.

Ribbon glass has been produced in a thin, continuous, pure and somewhat flexible form. It has been made in thicknesses ranging from 0.001 to 0.030 in. and in widths from ⅛ to 14 in. Although it is currently available only in a lead-potash type glass, use of other types of glass would broaden considerably the property range of the material. Though more flexible than other forms, ribbon glass is not completely flexible nor resistant to mechanical shock.

At present, ribbon is being used in the manufacture of capacitors. Future possible uses include transformer insulation and motor and armature slot insulation. It also would seem to be a promising material for use with other materials such as plastics.

Electrically conductive transparent glass is formed by applying a thin coating of a metallic semiconducting material to the glass surface. The coating can operate at 650 F and dissipate up to 15 watts per sq in. in air. The coating can be made so thin that light transmission is not seriously affected. Light transmittance through the coated glass can vary between 70 and 88% and resistivity values across the surface can range upward from 6 ohms per square.

There are four major types of

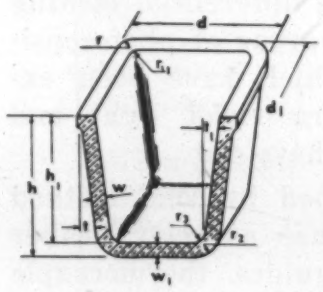


Owens-Illinois Glass Co.

Extremes of container design *are indicated by this plain olive bottle, and the squat, ornate footed tumbler used for preserves or jellies.*

PRESSED GLASSWARE DESIGN

Method of Manufacture		Size Group	Smallest Desirable Production Run, Pieces	d Dia or Width (Usual Range) in.	h Depth or Height (Usual Range) in.	h_1:d Depth vs Dia Max Ratio	d:d_1 Length vs Width, Max Ratio	w Wall Thick (Usual Range) in.	Weight
Block or Open and Shut Mold	Hand	Small	1200	1–3	1–5	1.5:1	2:1	5/32–¼	8 oz
		Medium	800	3–6	1–8	2:1	2:1	3/16–⅜	5 lb
		Large	500	6–24[a]	1½–12[a]	1.5:1	2:1	¼–½	20 lb
	Machine	Small	50,000	¾–1½	½–1½	1:1	1:1	3/32–5/32	2 oz
		Medium	35,000	2–6	¾–6	1.75:1	1.5:1	5/32–5/16	3 lb
		Large	25,000	6–18[a]	1–12[a]	1.5:1	1.5:1	¼–⅝	10 lb
Font Mold	Hand	Small	1200	¼–⅝	½–3	—	—	—	2 oz
		Medium	800	⅝–1	1–7	—	—	—	8 oz
		Large	500	1–2½	2–10	—	—	—	5 lb
	Machine	Small	50,000	¼–⅝	½–3	—	—	—	2 oz
		Medium	35,000	⅝–1	1–7	—	—	—	8 oz
		Large	25,000	1–2½	2–10	—	—	—	4 lb

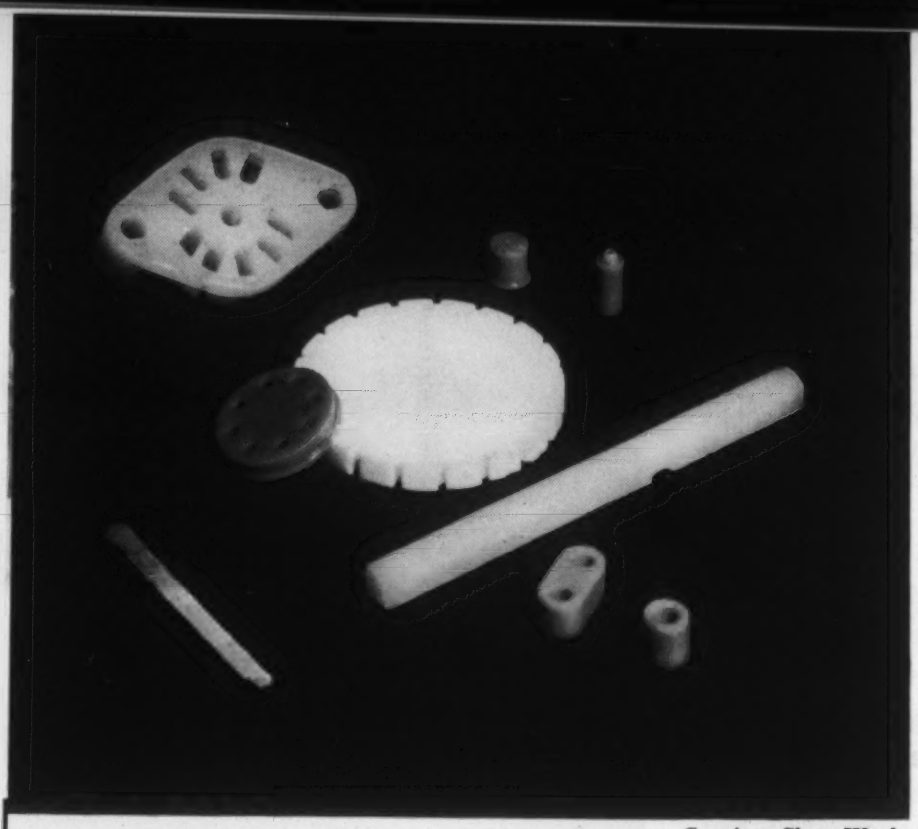


Side Wall Thickness			Bottom Thickness				
						Tolerance on W_1, % ±	
h^1, in.	Min W, in.	Tolerance on W, in. ±	h^1, in.	Min W_1, in.	Ratio h:d	Hand Produced	Machine Produced
1–4	⅛	.025	1–4	3/16	Up to 1	8 to 12	4 to 8
4–8	3/16	1/32	4–8	5/16			
8–12	¼	3/64	8–12	⅜	Over 1	25 to 50	15 to 30

Normal Tolerances on Outside Dimensions, in.		Min Desirable Fillets and Radii, in.			Desirable Side Tapers or Drafts					
					Exterior (Block Molds)			Interior		
d or h	Tolerance, ±	d or h	r, r_2	r_1, r_3	h, in.	Normal t, deg	Min. t, deg	h_1, in.	Normal t_1, deg	Min. t_1, deg
1–4	1/32	1–4	⅜	¼	1–4	2	1	1–4	3	2
4–8	3/64	4–8	½	⅜	4–8	3	1½	4–8	4	2
8–12	1/16	8–12	1	¾	Over 8	4	1½	Over 8	5	2

[a]Maximum dimension.

Source: Corning Glass Works, Bulletin B-84.



Corning Glass Works

Sintered glass parts *can be produced by either dry-pressing or slip-casting and sintering. Parts indicate wide variety of shapes possible.*

Corning Glass Works

Ribbon glass *is used in fixed glass capacitors.*

application for glass with electrically conductive coatings: 1) Heat source. Used for de-icing of aircraft, ships, and railroad glazing, and as space heaters. 2) Antistatic surface. Used to prevent accumulation of static charges on dielectric surfaces and on face plates of electrical instruments. 3) Electrical field. Used to create electrical fields for special lighting effects, such as activation of neon signs that need no connections. 4) Stable resistance characteristics. Coatings can be made insensitive to temperature change. This property coupled with good chemical stability makes the material suitable for use in precision resistors. (For further information about conductive glass, see M&M, Aug '56, p 108.)

Block glass is made by fusing together two halves of pressed glass to form a hollow, partially evacuated block. Blocks are used primarily in architectural applications, such as light-transmitting walls, interior partitions, etc.

Photosensitive glass can be "chemically machined" to form extremely accurate mechanical and electrical parts. Basis of the method is the differential etching rate between areas of photosensitive glass which have been exposed to ultra violet light and those which have not.

Parts formed by this method have found use as relay pusher bars, stylus guides, thermocouple wire guides, jigs for detailed assemblies, and screens in electronic storage tubes. (For further information on photosensitive glass, see M&M, June '56, p 134.)

Other radiation sensitive glasses. There are three other types of radiation sensitive glasses. *Color transparency* glass contains minute amounts of gold as a photosensitive metal. Portraits and other photographic reproductions can be developed either in line form or in continuous color tones. *Opal glass* is formed by introducing silver into the glass and promoting nucleation of the silver particles and growth of nonmetallic crystals from the nucleated silver particles. *Gamma ray sensitive* glass (mentioned in the flat glass section) fluoresces when exposed to ultra violet light after having been exposed to gamma rays. It is used in dosimeters carried by personnel to measure amounts of radiation.

Pittsburgh Plate Glass Co.

Glass-metal seals *join face plates to metal frames in these RCA 21-in. color TV tubes.*

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Acknowledgment

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Pittsburgh Corning Corp.
Pittsburgh Plate Glass Co.

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MATERIALS ENGINEERING FILE FACTS

Comparative Properties of Organic Coatings

	Vinyl-Alkyd (approx 1:1 ratio)	Vinyl (100%)	Silicone-Alkyd (approx 1:1 ratio)	Epoxy (100%)
CHEMICAL RESISTANCE				
Exterior and Salt Spray Resistance	Excellent	Very Good	Excellent	Excellent
Solvent Resistance:				
Alcohols	Good	Excellent	Fair	Excellent
Gasoline	Excellent	Excellent	E after bake	Excellent
Hydrocarbons	Poor	Good	Poor	Excellent
Esters, Ketones, etc.	Poor	Poor	Poor	Fair
Chlorinated Solvents	Poor	Poor	Poor	Excellent
Beverages and Foods	Fair	Excellent	Poor	Excellent
Fruit Juices	Fair	Excellent	Poor	Excellent
Salts (all conc)	Good	Excellent	Fair	Excellent
Alkalis, Strong				
Dilute, up to 20%	G to 10% at r.t.	E to 180 F	Poor	Excellent
Conc, over 20%	Poor	E to 180 F	Poor	Excellent
Ammonia	Poor	E-fumes, G-immersion	Poor	Poor
Mineral Acids:				
Dilute, up to 10%	Very Good	Excellent	Good	Excellent
Medium, 10–30%	Good	Excellent	Poor	Very Good
Conc, over 30%	Poor	Good	Poor	Good
Oxidizing Acids:				
Dilute, up to 10%	Poor	Excellent	Poor	Good
Medium, 10–30%	Poor	Very Good	Poor	Poor
Conc, over 30%	Poor	Good	Poor	Poor
Organic Acids (acetic, formic, etc.)				
Dilute, up to 10%	Good	Excellent	Poor	Good
Medium, 10–30%	Fair	Poor	Poor	Fair
Conc, over 30%	Poor	Poor	Poor	Poor
Organic Acids (oleic, stearic, lactic, etc., all conc)	Excellent	Excellent	Good	Excellent
Phosphoric Acid	Fair	Excellent	Poor	Poor
Water, Salt and Fresh	Excellent	Excellent	Good	Very Good
PHYSICAL PROPERTIES				
Sward Rocker Hardness (after 7 days)	26	20	16	36
Flexibility	Very Good	Excellent	Good	Excellent
Abrasion Resistance (Taber CS-10 wheel), cycles	2500	>5000	1000	>5000
Temperature Limit, F	200	180	1000	400
Adhesion to:				
Wood, Masonry	Excellent	Excellent	Excellent	Very Good
Ferrous Metals	Very Good	VG over wash coat primer	Very Good	Excellent
Nonferrous Metals	VG over wash coat primer	VG over wash coat primer	Fair	Excellent
Old Paints	Good	Poor	Excellent	Poor
APPLICATION				
Ease of Application	Dries faster than ordinary paints	Like lacquer	Like ordinary paints	Catalyst addition required
Metal Surface Preparation	Primer	Primer	No primer	No primer
Solvent for Application	Ketone	Ketone	Mineral spirits or turpentine	Ketone
Drying Time:				
Touch	15 min	15 min	45 min	45 min
Handle	2 hr	30 min	2 hr	2 hr
Hard	6–8 hr	4–6 hr	12 hr	12 hr
Re-coat	4–6 hr	4–6 hr	4–6 hr	6–8 hr
Corrosion Resistance	6 hr	24 hr	12 hr	7–10 days
Coverage, sq ft/gal/1-mil coat	300	250	500	450
Cost, ¢/sq ft/1-mil coat	1½	2½	2½	2
Avg Thk per Coat, mil	1.2	1.0	0.6	1.8

Note: E=Excellent; VG=Very Good; G=Good; F=Fair; P=Poor.

For more information, Circle No. 442

TUBING MACHINABILITY

. . . and product cost

Machinability of tubing is vitally important to producers of hollow cylindrical parts. But in the last analysis, final production *cost* is the real determining factor. Consequently, choosing the mechanical tubing that will easily machine to the quality finished part you demand and also hold final cost to the minimum, requires careful consideration of all the factors involved.

Matching the tubing to your own product needs and production equipment is important. Getting — in the tube — as many as possible of the characteristics and properties desired in the finished part, is equally important. Finish, heat treatment, tolerances, steel quality, alloy factor—any or all of these can be supplied within the original B&W mechanical tubing, to either eliminate or to reduce your machining and other production operations.

Because B&W mechanical tubing is tailor-made to suit your combination of production conditions and product specifications, you win on all counts. You'll find that the machining characteristics of the B&W tubing you select make it particularly suitable for your type of machine tool. Since you start with the desired properties, your production time and costs are pared to the bone.

B&W Regional Sales Offices, together with a nationwide network of B&W Distributors, are always prepared to serve you. You'll find Mr. Tubes — your link to B&W—always available to provide unbiased assistance in meeting your specific mechanical tubing requirements. The Babcock and Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy, and stainless steels

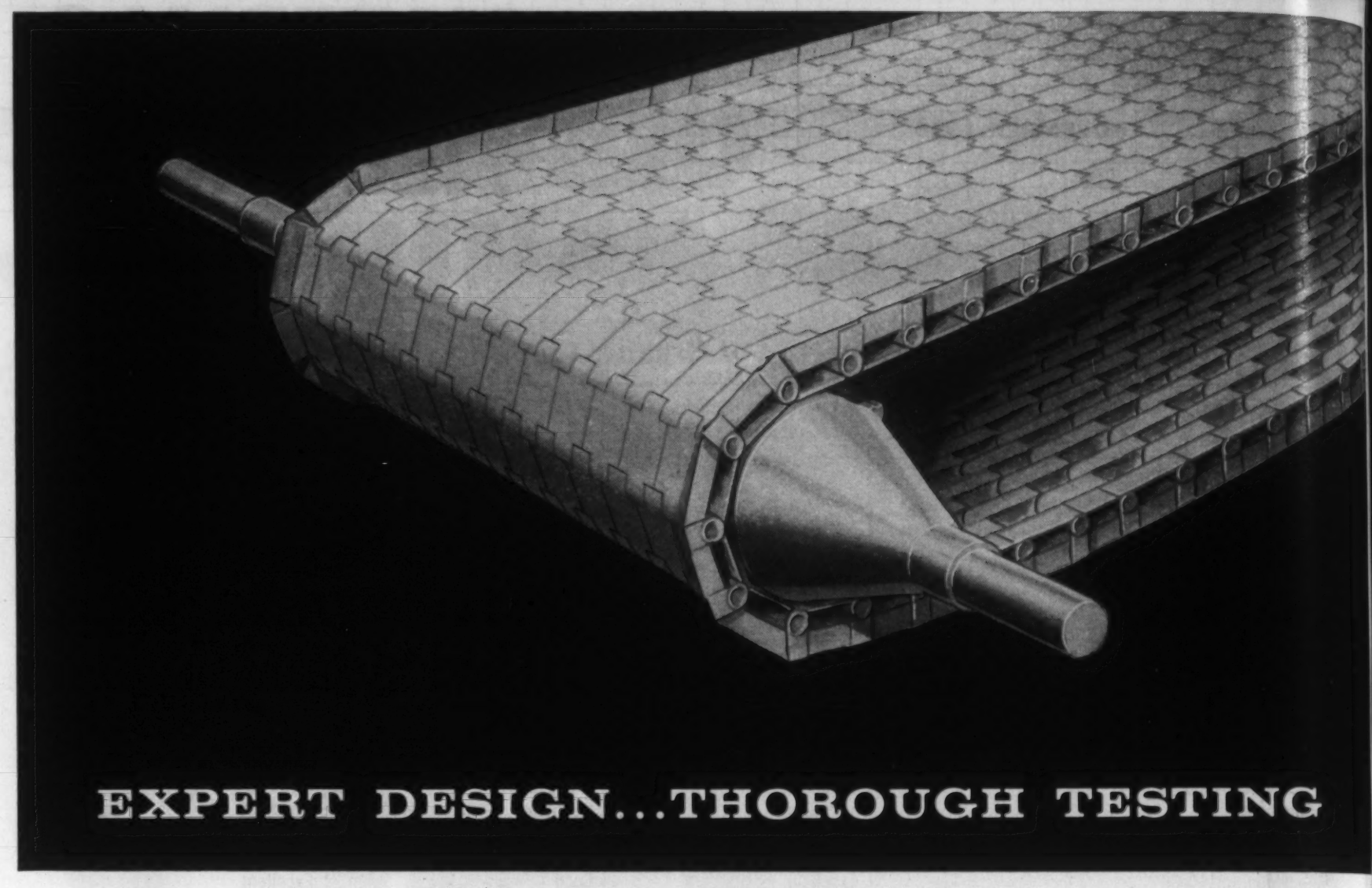
For more information, turn to Reader Service Card, Circle No. 578

Comparative Properties of Organic Coatings (continued)

	Epoxy-Phenolic (approx 1:1 ratio)	Chlorinated Rubber	Fluorocarbon (air-dried)
CHEMICAL RESISTANCE			
Exterior and Salt Spray Resistance	Excellent	Very Good	Good
Solvent Resistance:			
Alcohols	Excellent	Fair	Fair
Gasoline	Excellent	Good	Fair
Hydrocarbons	Excellent	Poor	Poor
Esters, Ketones, etc.	Excellent	Poor	Poor
Chlorinated Solvents	Excellent	Poor	Poor
Beverages and Foods	Excellent	Fair	Excellent
Fruit Juices	Excellent	Fair	Excellent
Salts (all conc)	Excellent	Excellent	Excellent
Alkalis, Strong			
Dilute, up to 20%	Excellent	E to 10%, G to 20% to 212 F	E to 212 F
Conc, over 20%	Excellent	F to 212 F	E to 212 F
Ammonia	Very Good	VG-fumes, G-immersion	Excellent
Mineral Acids:			
Dilute, up to 10%	Excellent	Excellent	Excellent
Medium, 10–30%	Excellent	Good	Excellent
Conc, over 30%	Excellent	Poor	Excellent
Oxidizing Acids:			
Dilute, up to 10%	Excellent	Excellent	Excellent
Medium, 10–30%	Very Good	Good	Excellent
Conc, over 30%	Poor	Poor	Excellent
Organic Acids (acetic, formic, etc.)			
Dilute, up to 10%	Excellent	Good	Excellent
Medium, 10–30%	Excellent	Poor	Excellent
Conc, over 30%	Very Good	Poor	Excellent
Organic Acids (oleic, stearic, lactic, etc., all conc)	Excellent	Excellent	Excellent
Phosphoric Acid	Excellent	Good	Excellent
Water, Salt and Fresh	Excellent	Very Good	Excellent
PHYSICAL PROPERTIES			
Sward Rocker Hardness (after 7 days)	44	24	20
Flexibility	Excellent	Very Good	Excellent
Abrasion Resistance (Taber CS-10 wheel), cycles	>5000	>5000	1000
Temperature Limit, F	400	250	212
Adhesion to:			
Wood, Masonry	Very Good	Excellent	Excellent
Ferrous Metals	Excellent	Very Good	VG over wash coat primer
Nonferrous Metals	Excellent	VG over wash coat primer	VG over wash coat primer
Old Paints	Poor	Excellent	Poor
APPLICATION			
Ease of Application	Like ordinary baking enamels	Like ordinary paints	Like lacquer
Metal Surface Preparation	No primer	No primer	Primer
Solvent for Application	Blend of ketone and alcohol	Aromatic hydrocarbon	Proprietary solvent
Drying Time:			
Touch	Bake only:	45 min	5 min
Handle	10 min at 450 F, or	2 hr	15 min
Hard	30 min at 400 F, or	4–6 hr	12 hr
Re-coat	60 min at 350 F, or	4–6 hr	12 hr
Corrosion Resistance	120 min at 310 F	24 hr	12 hr
Coverage, sq ft/gal/1-mil coat	450	450	250
Cost, ¢/sq ft/1-mil coat	1¾	1½	15
Avg Thk per Coat, mil	1.8	1.5	1.0

Note: E=Excellent; VG=Very Good; G=Good; F=Fair; P=Poor.

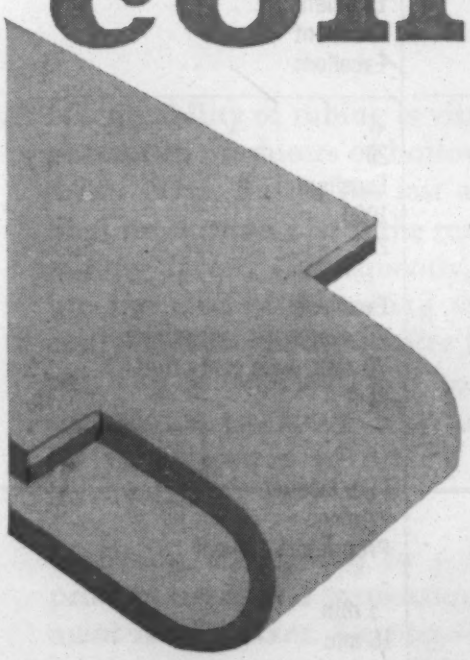
Courtesy of J. Landau Co.



EXPERT DESIGN...THOROUGH TESTING

Make the difference in

Thermalloy* conveyor belts



General-purpose
Typical 3" or 4" pitch center link of loop-type casting design.

It takes expert design *and* the right alloy to make conveyor belts that will stand up under your specific load and temperature conditions. That's why Electro-Alloys engineers first study the operating conditions of your installation . . . and why our metallurgical staff carefully controls the production of every high-heat-resistant Thermalloy conveyor part.

But design by itself isn't enough. We thoroughly test Thermalloy conveyor belts under actual load and temperature conditions! In our physical laboratory, a hot tensile machine constantly checks Thermalloy conveyor belts. Over a long period of testing in this machine, we've been able to establish load curves, apply tensions (up to 30 tons) to test short-time fractures and observe long-time creep. Finally, test runs are conducted at our plant as a control measure to assure proper operation of belts.

For further information on Thermalloy conveyor belts, write for Bulletin T-241, Electro-Alloys Division, 70211 Taylor Street, Elyria, Ohio.

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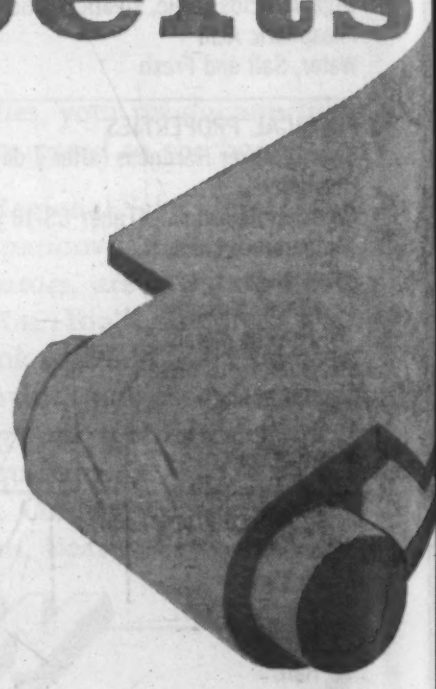

Heavy-duty
Typical heavy-duty link with integral cast pin to eliminate "crank-shafting".

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

For more information, turn to Reader Service Card, Circle No. 389

NEW MATERIALS PREVIEWS

This month

- *Teflon resin for extrusions*
- *A fluoro-silicone rubber*
- *Kel-F elastomer-coated nylon*

Extrudable Teflon Resin Now Under Evaluation

■ A Teflon resin with a melt viscosity low enough to permit extrusion on standard equipment has been developed by *E. I. du Pont de Nemours & Co., Inc.*, Wilmington, Del. It is now being evaluated as a supplement to conventional Teflon (polytetrafluoroethylene), which has such a high melt viscosity that it is fabricated by compressing and sintering techniques similar to those used in powder metallurgy. Pilot plant quantities of the new resin, designated Teflon 100X, will probably be available by early 1957.

Properties of Teflon 100X, as shown in the accompanying table, approach those of conventional Teflon. Electrical properties are essentially the same. Outdoor weatherability data are not available, but results of accelerated tests and electromagnetic absorption spectra studies indicate that the new resin should have unlimited outdoor life.

Chemical resistance of Teflon 100X seems to be identical with that of standard Teflon resins at temperatures up to 400 F. The resin is said to be completely inert to all known chemicals except alkali metals, fluorine at elevated temperatures and certain complex halogenated compounds, such as chlorine trifluoride. However, chemical inertness studies have not been completed.

At temperatures above 400 F the new resin has not measured up to standard Teflon. Anticipated maximum continuous service temperature is about 400 F, and intermittent service limit is 500 F where load bearing requirements are not great. At temperatures somewhat higher than 500 F, Teflon 100X softens to a melt.

The term "perfluorocarbon" has been adopted for Teflon 100X to distinguish it from conventional Teflon (polytetrafluoroethylene). Both resins are true fluorocarbons with saturated structures consisting of fluorine and carbon.

The new resin will be available in ⅛ in. cube-cut pellets. It can be readily extruded as film, tubing, wire insulation and other shapes.

TYPICAL PROPERTIES OF TEFLON 100X

Melting Point, F	545 to 563
Melt Viscosity, poises	6-8 x 10^4
Crystallinity (fabricated), %	
Quenched	40–50
Annealed 16 hr at 475 F	50–57
Annealed 1 mo at 410 F	50–57
Specific Gravity (fabricated)	
Quenched	2.145–2.16
Annealed	2.15–2.17
Ultimate Strength[a], psi	
73 F	2700–3100
453 F	450–500
Ultimate Elong[a], %	
73 F	250–330
453 F	150–250
Yield Point[a], (73 F), psi	1900
Flexural Modulus, psi	
73 F	80–85,000
212 F	15–18,000
392 F	5–8000
Heat Dist Temp (D 648), F:	
66 psi	162
264 psi	129
Brittle Temp (D 746), F	—130
Flammability (D 635-44)	Nonflammable
Hardness, Durometer D	55
Abrasion Resistance (Taber CS-17, 1000-gm cwt.), mg/1000 cycles	30–35
Therm Cond, Btu/hr/sq ft/F/in.	1.35
Coeff of Friction vs Steel (77–266 F)	0.09
Moisture Vapor Trans Rate, gm/100 sq in./day-mil	0.51
Water Absorption, %	0.0
Permeability (73 F), gm/100 sq in./day-mil:	
Water	0.02
Ethanol	0.10
Benzene	0.20
Carbon Tetrachloride	0.20
Piperidine	0.05
Acetophenone	0.50
Dielect Str (15-mil film), v/mil	1150–1550
Dielect Const (73 F, 100 cps-30 mc)	2.2
Power Factor (73 F, 100 cps-30 mc)	0.0002
Dielect Const (1000 cps, —40 to 464 F)	2.2
Power Factor (—40 to 464 F)	0.0002

[a] Micro tensile die (1½ in. overall length) proposed for ASTM standards on polytetrafluoroethylene. Crosshead speed = 2 in./min.

The ring of quality

Colorful, low-cost sidewall rings that can be quickly installed on tires are now contributing to the luxury-look of today's new cars. They're inexpensive, stay brilliant for life, wash bright in seconds, out-last tires. A product of The Bearfoot Sole Co., Wadsworth, Ohio, these rings are available in a variety of colors or in white. They're made of Enjay Butyl Rubber because no other rubber tested could equal its performance in severe laboratory and road tests. The Enjay Butyl label on the Flex-A-Wall® carton assures the buyer of outstanding quality.

Find out for yourself the many technical advantages of Enjay Butyl—the rubber that is outperforming natural and other types of rubber in a wide variety of industrial and consumer applications. For full information, and for technical assistance in the use of Enjay Butyl, write, wire or phone the Enjay Company.

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ENJAY *Pioneer in Petrochemicals*

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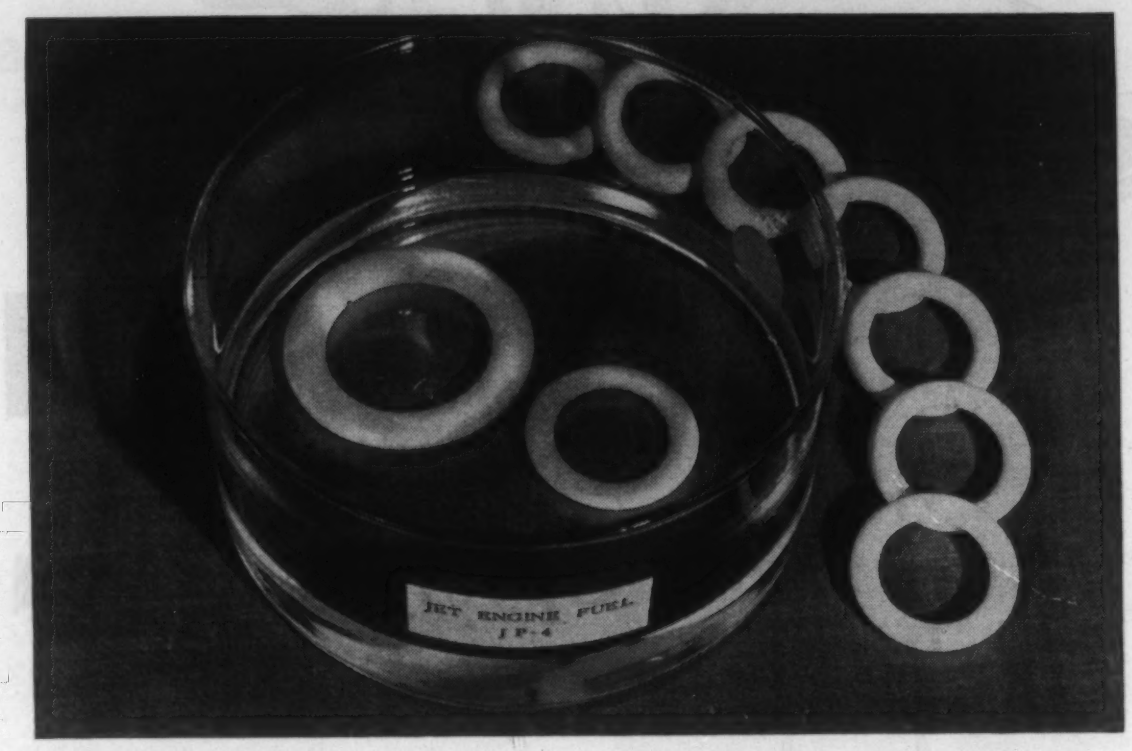
Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

For more information, turn to Reader Service Card, Circle No. 522



Comparison *of fluoro-silicone o-ring (right) with conventional silicone ring —originally same size—after 24-hr immersion in JP-4 jet engine fuel.*

Fluorine + Silicone Rubber =

New Heat and Solvent Resistant Elastomer

■ Newly developed fluoro-silicone rubber combines the temperature resistant elastomeric qualities of silicone rubber with the chemical resistance of the fluorocarbons. Developed by *Dow Corning Corp.*, Midland, Mich., in collaboration with Wright Air Development Center, the new rubber, called Silastic LS-53, is intended to meet service requirements for a low swell, heat stable rubber for use on jet powered planes.

Similar to other fluorocarbon elastomers (Kel-F elastomer & Poly FBA) at high temperatures, the fluoro-silicone rubber is said to have in addition outstanding resistance to swelling in contact with jet fuels, gasoline, high aromatic oils and certain solvents. Its elastomeric behavior is retained over a temperature range of —80 to 400 F. Tensile strength, ultimate elongation and compression set are comparable to those of conventional silicone rubbers. The new rubber can be fabricated by conventional methods used in forming silicone rubbers. It can be vulcanized in 5 min at 260 F, and should be post cured for 24 hr at 300 F in an air circulating oven. The accompanying tables list physical properties and indicate comparative fuel and solvent resistance.

Initial use of the material will be limited to o-rings and other seals for essential aircraft. For this type of application the rubber is available at $30 per 1-lb sample.

TYPICAL PHYSICAL PROPERTIES

Color	—	Red
Specific Gravity	—	1.4
Hardness[a], Shore A	D 676-49 T	50
Tensile Strength[a], psi	D 412-51 T	800
Elongation[a], %	D 412-51 T	250
Compression Set[b], %	D 395-53 T, Method B	30
Water Absorp, 70 hr at 212 F:		
Durometer Change	—	—2
Volume Change, %	—	+3
Brittle Point, F	D 746-54 T	—90

[a]Molded 5 min at 260 F; oven cured 24 hr at 300 F. [b]22 hr at 300 F.

OIL AND FUEL RESISTANCE[a]

Test Fuel	Conditions	Silastic LS-53		Silastic 50[b]
		Durometer Change, points	Volume Change, %	Volume Change, %
ASTM No. 3 Oil	70 hr/300 F	—10	+5	+63
MIL-H-3136 Type III (70% iso-octane, 30% toluene)	70 hr/rm temp	—8	+20	+225
MIL-O-7808 (diester base oil—Turbo Oil No. 15)	70 hr/350 F	—18	+5	+31
MIL-O-5606 (hydraulic fluid—Univis J-43)	24 hr/250 F	—10	+11	+163
Phosphate Ester Hydraulic Fluid	70 hr/250 F	—17	+11	+10
Silicate Ester Hydraulic Fluid (Monsanto OS-45)	70 hr/350 F	—19	—5	+77

[a]Based on 24 hr cure at 300 F. [b]Properties of conventional silicone rubber for comparison.

for **Acid** *resistance*

Specify SHARON STAINLESS STEELS

Wherever it is necessary for metal to come into contact with acids, you'll find more and more stainless steel being used.

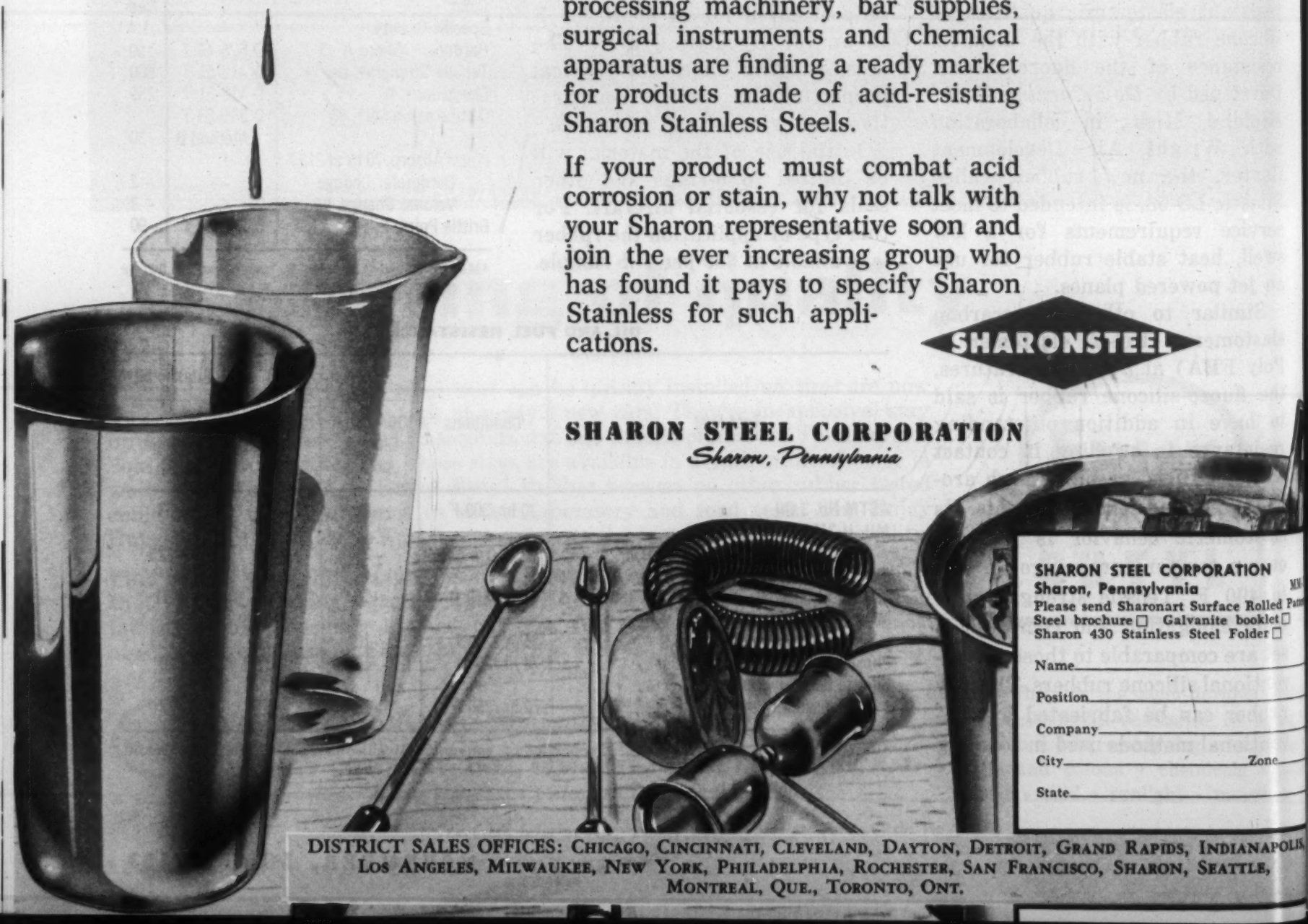
And why not? Isn't it just common sense to design and manufacture a product that will stand up under all conditions of its intended use?

Manufacturers of such items as kitchen utensils, cutlery and flatware, photographic equipment, tubing, food processing machinery, bar supplies, surgical instruments and chemical apparatus are finding a ready market for products made of acid-resisting Sharon Stainless Steels.

If your product must combat acid corrosion or stain, why not talk with your Sharon representative soon and join the ever increasing group who has found it pays to specify Sharon Stainless for such applications.

SHARONSTEEL

SHARON STEEL CORPORATION
Sharon, Pennsylvania



SHARON STEEL CORPORATION
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Fluorocarbon-Coated Nylon Resists Aircraft Fuels

■ Kel-F elastomer-coated nylon fabric is available in limited quantities from *Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn. The company is currently developing Kel-F elastomer-coated glass and Dacron fabrics. Possible applications of the coated fabrics are aircraft seal coverings and diaphragms.

The fluorocarbon elastomer, a product of M. W. Kellogg Co., is of interest because of its resistance to swelling and deterioration in JP-4 and JP-5 aircraft fuels and corrosive chemicals (table).

Because of the limitations of the fabric, the upper temperature limit of the coated nylon is only 200 F. However, Kel-F elastomer-coated Dacron fabric is expected to have an upper temperature limit of 400 F, and coated glass fabric will be good up to 480 F for short periods of time, 400 F for extended periods.

A sample of Kel-F elastomer-coated nylon fabric cooled from —20 to —85 F over a 4-hr period showed some change in flexibility but no signs of cracking in a 180 deg bend test.

TYPICAL PROPERTIES OF COATED NYLON FABRIC[a]

Tear Strength, lb/trapezoid	7 x 7
Elongation at Break, %	9 x 78
Mullen Burst, psi	100
Resistance to JP-4 Fuel, % vol incr:	
24 hr at Rm Temp	6.7
96 hr at Rm Temp	17.5
Resistance to JP-5 Fuel, % vol incr:	
24 hr at Rm Temp	1
96 hr at Rm Temp	2.6
Permeability to RFNA (8 hr), 8 gm HNO_3/sq in.	45

[a]Thickness: 9-10 mil. Weight: 11.8 02/sq yd. Finished width: 33 in.

OTHER NEW MATERIALS PRODUCTS

Tapes—Felt, Waterproof, Bonding

***Backing strip** is pulled away from felt tape to show adhesive tracks.*

1. Strong felt tape

An adhesive felt tape has been developed by *Spring Packing Corp.*, Dept. PR, 332 S. Michigan Ave., Chicago 4. Called Spring-Felt No. 124XN-T, it can be applied with finger pressure. The tape seals against dust, dirt, wind fumes and moisture and helps to eliminate squeaks and rattles. The tape is supplied in roll form and in die cut and segmented form.

2. Waterproof cloth tape

A multipurpose colored waterproof cotton cloth tape has been developed by *Permacel Tape Corp.*, New Brunswick, N. Y. Designated Permacel 68, the pressure sensitive tape combines good tensile strength (60 lb per in. of width) with a high degree of moisture resistance. Its adhesion averages 40 oz per in. of width to plastic and 32 to steel.

For color identification applications, the tape is supplied in assorted sizes in red, black, white, brown, yellow, dark blue, light blue, green, pink and olive drab. Typical uses include repairing, decorating, splicing, holding, edging and hinging. The tape is made to meet the following government specifications: PPP-T-0060 - Type III, Class 1; PPP-T-0060 - Type III, Classes 2 and 3 (where transparency is not required); and JAN-P-127 - Type 1, Grade B.

3. Bonding tape

A new Varband bonding tape is claimed to have good dielectric qualities and high thermal stability with no distortion or elongation. Developed by *Varflex Corp.*, Rome, N. Y., the tape is resistant to mild acids, alkalies, oil and grease. There is said to be no interference with magnetic fields and no arc-over danger.

The tape is made of hundreds of parallel fiberglass yarns uniformly coated and impregnated with polyester resin. It may be wound around wires as with ordinary tape, and the end can be heat sealed by a soldering iron, eliminating knots. Where desired, the material can be readily knotted and tied.

When cured, Varband bonding tape becomes a homogeneous machinable mass, thoroughly impregnated. Recommended curing time is 3 hr at 255 F or less time at a higher temperature.

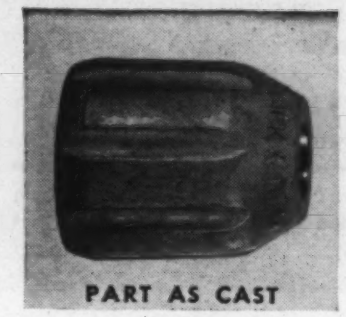
Armature banding, core and stator winding and coil tying supports are among the applications for which the tape is recommended. It is also used for anchoring wires in vibrating power tools or wire assemblies that rotate at high speeds. The tape is supplied in six standard widths ranging from 10 ends to 120 ends with a thickness of 0.015 to 0.030 in., or it can be made to meet specific requirements.

(more New Materials on p 166)

For more information, Circle No. 446

now

you can get this brilliant finish directly on zinc die castings!



PART AS CAST

No electroplating--no mechanical finishing!

TREATED WITH NEW IRIDITE

NEW IRIDITE® (Cast-Zinc-Brite)

brightens zinc die castings by chemical polishing, protects against corrosion

NOW, FOR THE FIRST TIME you can get a brilliant, decorative finish directly on zinc die-cast parts . . . without mechanical finishing, without electroplating! The luster is provided by the *chemical polishing* action of new Iridite (Cast-Zinc-Brite) solution. Even surface blemishes, such as cold shuts, are brightened by this new process. No electrolysis. No special equipment. No specially trained personnel. Just a simple chemical dip for a few seconds and the job is done. And, this new Iridite has been *tested and proved* in production.

CORROSION RESISTANCE, TOO! New Iridite (Cast-Zinc-Brite) provides exceptional corrosion resistance for bright-type chromate finishes . . . also guards against blueing or darkening by eliminating zinc plate formerly required in bright chromate finishing of zinc die castings.

AS A BASE FOR ELECTROPLATING—Lower mechanical finishing costs are possible where plated finishes are *required* since the brightness provided by this new Iridite may be sufficient.

LET US SHOW YOU what Iridite (Cast-Zinc-Brite) can do for you. Send us at least a half-dozen typical zinc die-cast parts for FREE PROCESSING for your own tests and evaluation. Or, for immediate information, call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified 'phone book. *IMPORTANT: when you give us samples for test processing, please be sure to identify the alloy used.*

Iridite is approved under government specifications

ALLIED RESEARCH PRODUCTS
INCORPORATED
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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals

For more information, turn to Reader Service Card, Circle No. 411

OTHER NEW MATERIALS PRODUCTS

Nonwoven Fabric for Battery Separators

New 12-v batteries will have almost the same size exterior case as was formerly required by 6-v batteries. The battery separator material that makes this possible is a nonwoven fabric made with Dynel staple fiber. Called Dynel-Mat, it is made by *Felters Co.*, 210 South St., Boston, Mass. A thickness of only 1/32 in. is required, compared to the ⅛ in. or more in thickness required by wood type separators.

Dynel-Mat is claimed to have high resistance to sulfuric acid and good dimensional stability. It is made in rolls and sheets, various densities, thicknesses and surfaces, depending on the type of resin binder used.

Chemical Wire Stripper

A noncorrosive chemical wire stripper has been developed by *Hi-Grade Alloy Corp.*, 1236 S. Talman, Chicago 8, Ill. It is claimed to remove most synthetic enamel type insulation from magnet wire in less than 15 sec. Called Hi-Grade No. 70 Chemical Wire Stripper, it will remove Formex, Formvar, oleoresinous enamels, silicone enamels, polyester enamels and most synthetic enamels.

Lubricant for Nylon Improves Bearings

A lubricant for nylon has been developed to provide a dry seal against oxidization and contamination of bearing surfaces. Called Nylube, it is marketed by *Synco Co.*, United Artists Bldg., Detroit 16, Mich. The material is claimed to have proved efficient in providing longer, quieter, smoother operation; reduced maintenance costs; and elimination of warping, dust, rust, lint and corrosion.

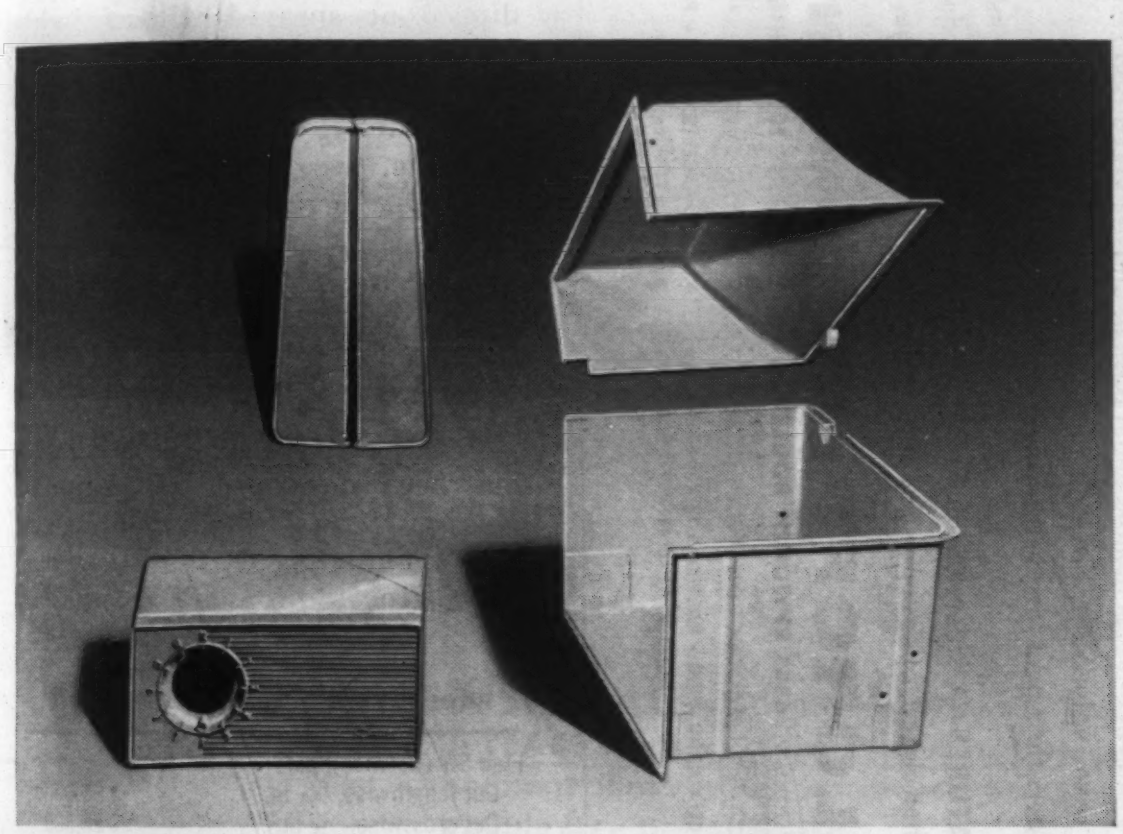
The dry base lubricant utilizes

NOVEMBER
1956

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

THE IMPORTANCE OF CONTROLLED PRESSURE IN PLASTICS MOLDING



Recent developments in controlling plastics pressure have made it now possible to mold large, complex shapes, such as the radio cabinet, refrigerator liner and luggage end caps.

The disposable cup exemplifies the uniform quality product now demanded of materials and processes in fully automatic, high-speed molding. These cups were molded from Styron 689, a new general purpose formulation with greatly improved properties of easy flow.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

A CONTINUING REPORT

Results of Dow Plastics Technical Service research will appear in these pages from time to time. For a complete summary of Dow products and services, write: THE DOW CHEMICAL COMPANY, Midland, Michigan—Plastics Sales Department PL 429H.

INJECTION MOLDING RESEARCH SHOWS WAY TO BETTER TECHNOLOGY

In the continuing Plastiatrics studies under the direction of Dow Plastics Technical Service, one of the most rewarding areas of investigation for meeting more exacting needs today has been in the control of plastics pressure.

Beginning with the remarkable results of the early "pinpoint gate", considerations for equalizing pressure distribution in the molding system have assumed greater importance. Mechanical aids, such as the "free-flow" and "ball-check" nozzles, were adopted. Thermal studies on the effect of mold heats have made die temperature control units commonplace. Later findings that pressure control is directly related to the accuracy with which granules are fed to the heating cylinder led to the adoption of weigh feeders and pre-plasticizers for top efficiency.

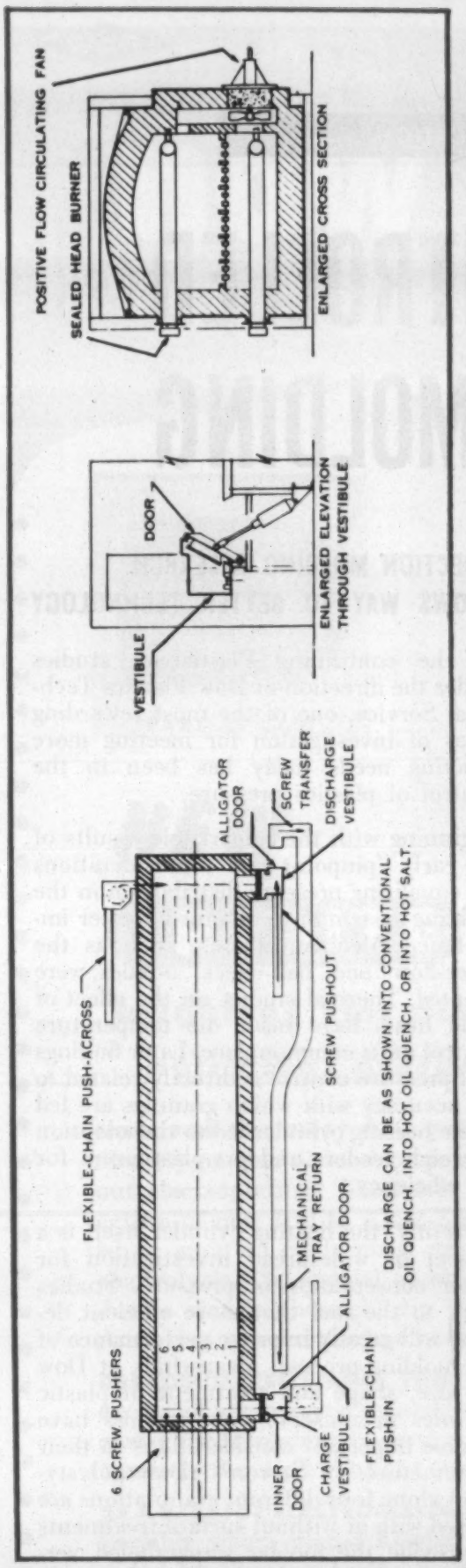
Currently, the heating cylinder itself is a subject of widespread investigation for better conservation of pressure. Studies point to the fact that more efficient designs will greatly improve performance of the molding process. Meanwhile, at Dow the size, shape and treatment of plastic granules to conserve pressure loss have become important considerations in their manufacture. In Styron® (Dow polystyrene) alone four different granulations are offered with or without surface treatments to provide the molder unparalleled versatility in meeting design requirements.

The practical benefits of continuing Plastiatrics studies, such as those on pressure control, result in leadership. In Dow plastics you will find the better quality of materials more meaningful because they are realistically designed to perform for you. Ask for your copy of "Injection Molding Research Today and Tomorrow" or get in touch with your Dow representative for more complete information.

you can depend on
DOW PLASTICS

DOW

For more information, turn to Reader Service Card, Circle No. 482



LET'S TALK THE LATEST IN FURNACE DESIGN

Visualize six rows of stock—each row may be of a *different* size and shaped part and may move at a *different* rate of speed through the furnace. *That's real versatility!*

This is the nutshell story of a new Holcroft design. Here are more facts:

HEATING—Sealed head radiant tube burners heat the installation. Air and fuel are metered and progressively mixed as they pass through the tubes providing maximum efficiency at all rates of heating. A positive flow circulating fan assures even distribution of heat and atmosphere around the work.

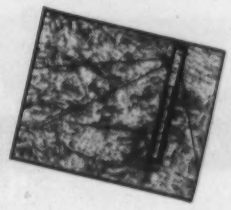
MATERIAL MOVEMENT—Work trays push each other over silicon carbide rails. Ball bearing type screw pushers are used. An unusual flexible chain push in and push across saves valuable space and permits the use of smaller doors (less heat loss, less purging gas).

OTHER FEATURES—A safety-designed alligator door is air tight when closed, opens upon gas or power failure.

Used with the Lo-Dew gas generator, a wide variety of processing (carbo nitriding, carburizing, clean hardening, carbon restoration, etc.) can be handled.

• • •

If you run a mixed production schedule or "all alike" parts—you'll do best to look carefully at what Holcroft can do for you. Better do it right now. Just write!



BLAZING THE HEAT TREAT TRAIL WITH HOLCROFT

HOLCROFT AND COMPANY

6545 EPWORTH BOULEVARD • DETROIT 10, MICHIGAN

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

CHICAGO, ILL. • CLEVELAND, OHIO • HARTFORD, CONN. • HOUSTON, TEXAS • LOS ANGELES, CALIF. • PHILA., PA.

CANADA: Walker Metal Products, Ltd., Windsor, Ontario

For more information, turn to Reader Service Card, Circle No. 503

OTHER NEW MATERIALS PRODUCTS

the principle of regelation, becoming wet and slippery as pressure is applied, then resolidifying instantly as pressure is relieved. Consequently, it lubricates without becoming greasy or runny. Only small quantities are required for efficient operation. Parts are dipped or sprayed with a light film that is replenished as needed to keep bearings sealed and running quietly. The average reapplication, according to Synco, is every six months.

Electrical Laminate Has Low Cold Flow

A new electrical grade laminate has been developed by *National Vulcanized Fibre Co.*, 1056 Beech St., Wilmington 99, Del. It is designed for radio and TV applica-

PROPERTIES OF PHENOLITE E-2040

Flex Str (flatwise), psi:	
Cut lengthwise, 1/16 in.	31,000
Cut crosswise, 1/16 in.	26,300
Cut lengthwise, 1/8 in.	30,200
Cut crosswise, 1/8 in.	23,100
Impact Str, (edgewise, cond E-48/50), ft-lb/in.:	
Cut lengthwise, 1/8 in.	0.60
Cut crosswise, 1/8 in.	0.56
Water Absorp (cond E-1/105, then cond D-24/23), %:	
1/16 in.	0.42
1/8 in.	0.22
Density	1.37
Rockwell Hardness:	
Cold	117M
Hot (60 sec)	82
Hot (120 sec)	107
Cold Flow, div change	8.1
Dissip Fact (1 mc):	
Cond A, 1/16 in.	0.0302
Cond D-24/23, 1/16 in.	0.0310
Dielec Const (1 mc):	
Cond A, 1/16 in.	4.56
Cond D-24/23, 1/16 in.	4.63
Dielec Str (par. to laminations), kv:	
Cond A, 1/8 in.	55 FL
Cond D-48/50, 1/8 in.	65 FL
Dielec Str (par. to laminations, in oil, cond A, 1/16 in.), v/mil	1030
Insulation Resist (11/16x1 1/8-in. samples, tapered pins with 1/2-in. centers), megohms:	
Cond A	10^6
Cond D-24/23	71,000

EFFICIENT • FLEXIBLE • COMPACT

Murray-Way's New #55 Head

GIVES YOU THESE POLISHING AND BUFFING ADVANTAGES:

GUARANTEED SPINDLES—All Murray-Way 55 Spindles are GUARANTEED FOR 3 YEARS. Factory-tested spindles incorporate heavy-duty, anti-friction bearings that require no grease or oil and are sealed against dirt for trouble free performance.

RIGHT OR LEFT HAND OPERATION—By simply inverting the head assembly, the 55 Heads may be used for either right or left hand operation.

SMALL FLOOR SPACE—The 55 Series Heads will install in line on 5′8″ centers. They conserve floor space, economize on conveyors, and reduce fixture requirements.

UNIVERSAL POSITIONING—With the Murray-Way adjustable fulcrum head, you get universal positioning by means of simple, accessible adjustment controls at the front of the head.

RUGGED—These heads are truly heavy-duty workhorses with 30 H.P. capacity.

FULL WORK CONTACT—On even the most irregular work shapes, Murray-Way's 55 Heads remain in constant contact—NO EXTRA PASSES—LOWER OPERATING COST—MORE PRODUCTION.

The technical know-how of Murray-Way's experienced engineers is the reason that production men who want a BETTER WAY . . . SPECIFY MURRAY-WAY.

FOR COMPLETE INFORMATION WRITE

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MURRAY-WAY CORPORATION

P. O. BOX 180, MAPLE ROAD EAST • BIRMINGHAM, MICH.

Polishing, Buffing, Grinding, Filtering Equipment that automatically cuts your costs.

For more information, turn to Reader Service Card, Circle No. 489

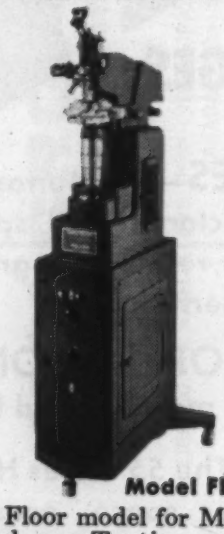
ACCO products

Wilson "Tukon" Micro Hardness Testers

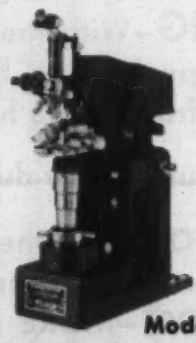
UNEXCELLED
for testing fine parts...
METALLIC and NON-METALLIC

Model LR
Floor model for Micro and Macro Hardness Testing.

WILSON "TUKON" Micro Hardness Testers meet every fine test requirement. These precision instruments are invaluable in the proper testing of fine precision parts, fine wire, thin metal, shallow superficially hardened surfaces, jewels, plastics, glass, etc. WILSON "TUKON" testers operate with both Knoop and 136 degree Diamond Pyramid Indenters.



Model FB
Floor model for Micro Hardness Testing only. (Electrically operated)



Model MO
Table model for Micro Hardness Testing only. (Mechanically operated. Also available in floor model)

Consult with WILSON Engineers on your hardness testing problem

Experienced WILSON Engineers will be glad to help you select the proper model for your particular requirement. This choice depends on the type and thickness of work to be tested, range of loads and other hardness testing equipment available.

Write for Booklet **DH-328** *on WILSON "TUKON" Micro Hardness Testers. Ask for* **DH-325** *on WILSON "ROCKWELL" Hardness Testers.*

WILSON "ROCKWELL"...
the world's standard of hardness accuracy

ACCO
Wilson Mechanical Instrument Division
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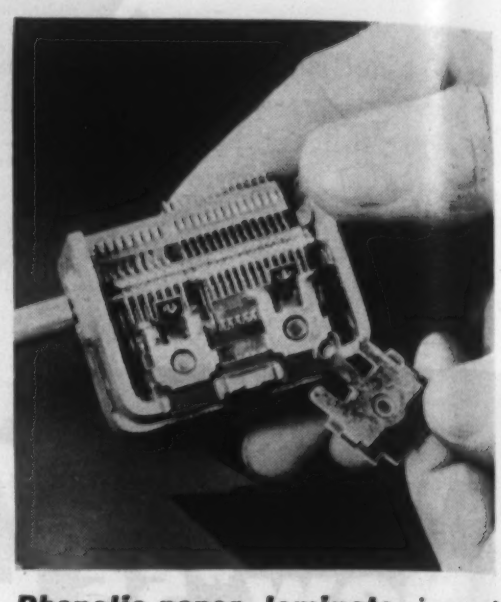
230-E Park Avenue, New York 17, N. Y.

for Better Value

OTHER NEW MATERIALS PRODUCTS



Phenolic-paper laminate *is used here for terminal insulators on a variable condenser.*

tions where good electrical properties and low cold flow are important. Known as Phenolite E-2040, it is a phenolic-impregnated paper-base sheet laminate. It is reported to have low moisture absorption, ease of hot punching and shearing, and good dielectric strength, both perpendicular and parallel to the laminations.

Phenolite E-2040 is supplied in sheets up to 39 x 47 in. and in thicknesses from 0.010 to 0.25 in. Color is natural and finish is dull. Physical and electrical properties are shown in the accompanying table.

Two Cleaners and a Rust Preventive

1. Nonferrous precleaner

A new type of water soluble compound precleans nonferrous metallic surfaces for plating and finishing operations. Designated "449," the cleaner is marketed by *Northwest Chemical Co.*, 9310 Roselawn Ave., Detroit 4, Mich. It is a single compound and has unusually long bath life. Nontoxic and harmless to equipment and rack coatings, the cleaner poses no fire hazards.

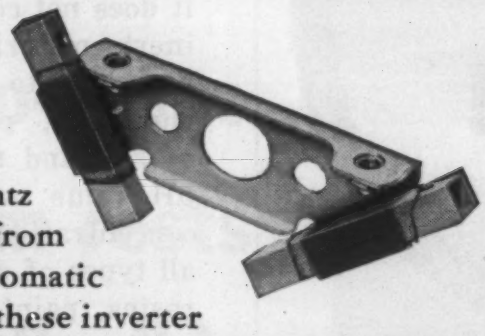
2. Noncaustic detergent

A safety cleaner that is reported to be a clean-to-handle,

For more information, turn to Reader Service Card, Circle No. 559

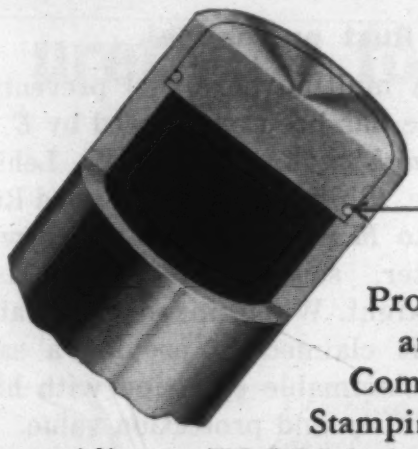
7 WAYS to SAVE MONEY with TOCCO* Induction Brazing

1



$15.84 per hour was saved by Jack & Heintz when they switched from torch brazing to automatic induction brazing of these inverter brush mounts. TOCCO brazing also upped production from 40 to 360 brazed assemblies per hour.

2

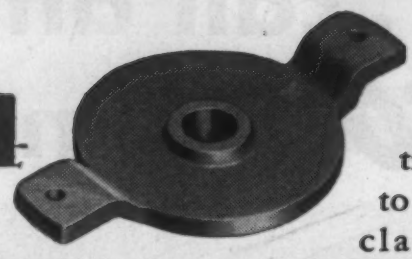


Production was doubled and cost cut 50% when Commercial Shearing and Stamping Company changed from welding to TOCCO induction brazing of these hydraulic cylinder assemblies. Heating time was cut from 15.3 minutes to 2 minutes on 5¼" cylinder shown here.

3

Willey's Carbide Tool Co. cut cost of brazing tips on large lathe tools from 58¢ to 4¢ when they adopted TOCCO induction brazing. Production is 8 times as fast with TOCCO—85 per hour, against 80 per day produced by a former method.

4

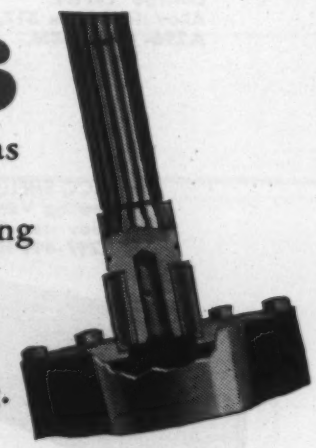


Formerly, Norris Thermador Corporation used arc welding to join this bushing and clamp. The change to TOCCO induction brazing reduced their costs 32% —from $46.44 to $31.73 per thousand parts.

5

When Mechanics Universal Joint Division of Borg-Warner shifted from welding to TOCCO induction brazing of this drive shaft assembly, they reduced the cost of the operation 67%. At the same time automatic TOCCO increased production from 11 to 45 pieces per hour—400% faster than the former method.

6



Packard engineers saved $1.74 per part when this automatic transmission shaft was redesigned from a forging to a steel shaft and casting, permitting the use of TOCCO induction brazing. In addition to this per part saving, $74,325 was saved in equipment and tooling.

7 Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for smililarly money-saving results—without obligation, of course.

THE OHIO CRANKSHAFT COMPANY

TOCCO

*Trade Mark Reg. U. S. Pat. Off.

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NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. T-11, Cleveland 5, Ohio

Please send copy of "Typical Results of TOCCO Induction Brazing and Soldering."

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For more information, turn to Reader Service Card, Circle No. 468

BEFORE YOU SAY,
"IT CAN'T BE CAST"
...call an
ESCO engineer!

ESCO SHELLCAST carbon steel conveyor link.

ESCO SHELLCAST Valve Linkage Levers. Alloy steel Type 317, A296- 49T CF-8M.

ESCO alloy steel castings can make your designing *easier.* You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time—

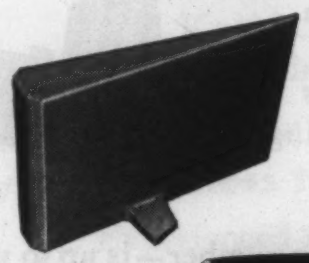
PLUS **Metallurgical Engineering and Research.** *ESCO* maintains one of the largest and best equipped metallurgical staffs of any alloy steel foundry—

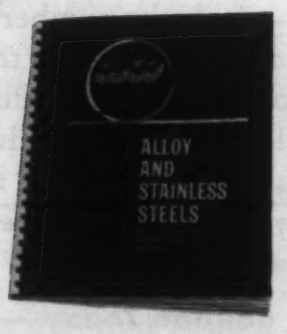
PLUS **Product Engineering and Design.** An integrated service at all levels; in the field, at the drawing board and in the foundry—

PLUS **Foundry Facilities and Casting Experience.** A casting service that covers the complete range of alloy steel casting methods for all applications—

PLUS **Laboratory Inspection and Testing.** *ESCO* laboratory technicians are qualified and equipped to perform all types of inspections and testing to the most rigid specifications.

ESCO SHELLCAST Heat-treating Vane tip. Alloy steel Type 302B, A297-49T HF.





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Write today for your *FREE* copy of this informative 100-page reference book—"ESCO Alloy and Stainless Steels for the Process and Manufacturing Industries".

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For more information, turn to Reader Service Card, Circle No. 459

OTHER NEW MATERIALS PRODUCTS

dustless, free-flowing powder is marketed by *John B. Moore Corp.*, Nutley 10, N. J. Called Nocaust NC 200, it is highly alkaline, but it does not contain free caustic or inert material. Claimed to be harmless to metals, the cleaner emulsifies, prevents redeposition of soil and maintains a constant pH value over a wide range of concentrations. It can be used in all types of operations where oils, resins, paints, dirt and all other matter must be removed from metal or nonmetallic surfaces.

3. Rust preventive

A multipurpose rust preventive base has been announced by *E. F. Houghton & Co.*, 303 W. Lehigh Ave., Philadelphia 33. Called Rust Veto M.P., it can be mixed with water, solvent or oil or used straight. When mixed with water, it is claimed to provide a safe, nonflammable emulsion with high stability and protection value.

Copper-Clad Steel for Spring Conductors

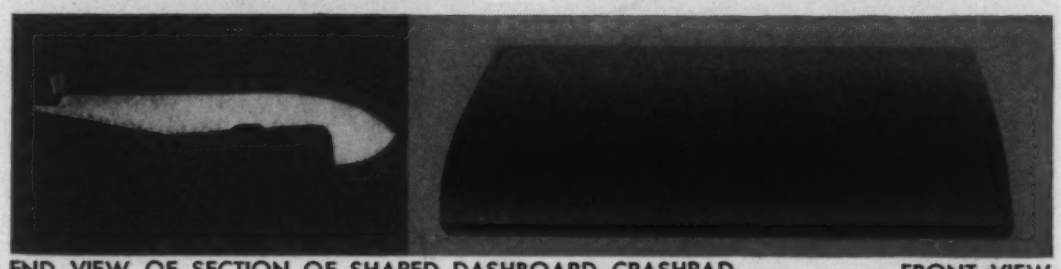
Consisting of medium carbon hardenable steel (SAE 1065) clad on one or both sides with oxygen-free, high conductivity copper (OFHC), a new clad metal combination, called Conflex, has been developed by *General Plate Div., Metals & Controls Corp.*, 43 Forest St., Attleboro, Mass. The composite metal features high conductivity, excellent spring characteristics by heat treatment, resistance to corrosion, ductility for extreme forming with long tool wear, and good operating characteristics at elevated temperatures.

The metals are bonded by a solid phase bonding process without the use of brazing alloys or other intermediate materials. This process is said to produce a composite metal having a continuous permanent bond.

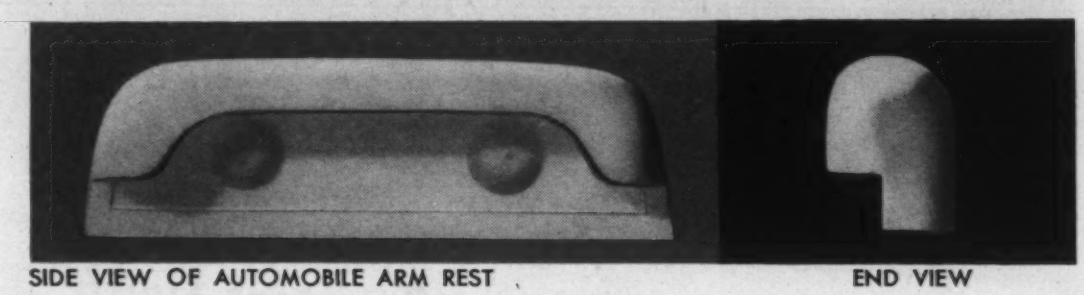
The standard cladding ratio with copper on one side is 80-20 (80 steel and 20% copper). With

Molded-to-shape seats, arm rests of flexible urethane foam

SIDE VIEW OF AUTOMOBILE ARM REST — END VIEW



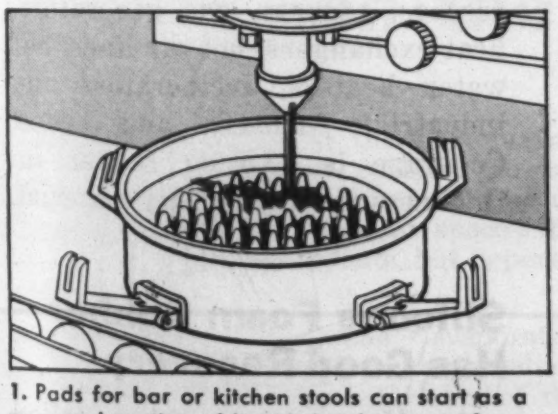
END VIEW OF SECTION OF SHAPED DASHBOARD CRASHPAD — FRONT VIEW



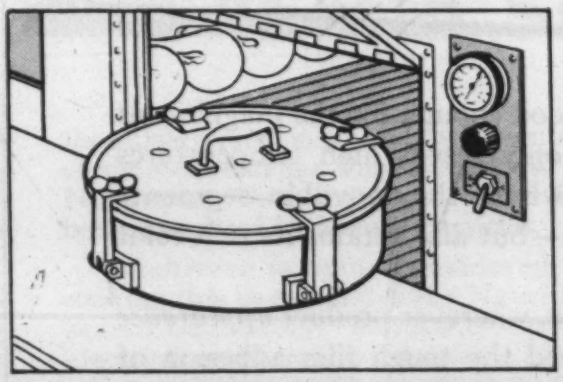
SIDE VIEW OF AUTOMOBILE ARM REST — END VIEW

■ *Cushion-y urethane foams in a wide range of densities, in varying degrees of firmness—can be custom molded by foam makers into shaped seat pads, arm rests, head liners . . . for automobiles, busses and street cars, planes, and into dozens of consumer products.*

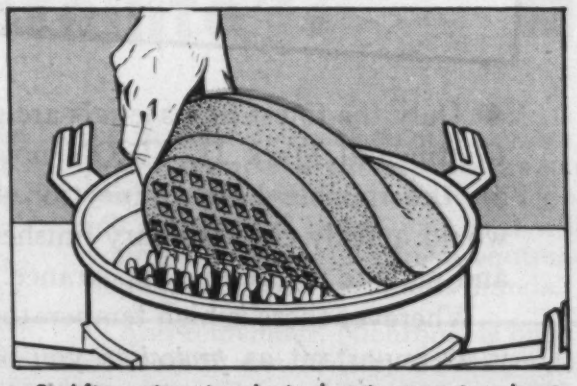
■ *The tough foamed part can then be hog-ringed to springs or bonded with adhesive to wood or metal. Foamed parts—molded to order—can simplify the manufacture of scores of products where comfortable seating or shock absorption is a major requirement.*



1. Pads for bar or kitchen stools can start as a measured portion of liquid that begins to foam within two seconds after pouring.



2. Original composition of liquid determines cell size and degree of softness. The liquid foams up to fill the mold's contours; can be foamed to shape with or without a surface skin.



3. After a twenty-minute, low temperature heat-cure—the flexible foamed part is taken from the mold—ready for use; can be "finished" with a colorful "leathery" gloss urethane coating.

MONSANTO

Monsanto does not make urethane foams, only the basic chemical raw materials. For your information on how molded urethane foams can serve you, write Monsanto for a list of manufacturers of urethane foam. These foam makers will be well-qualified to discuss your needs for molded foam products. Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Dept. ID-5, St. Louis 1, Missouri.

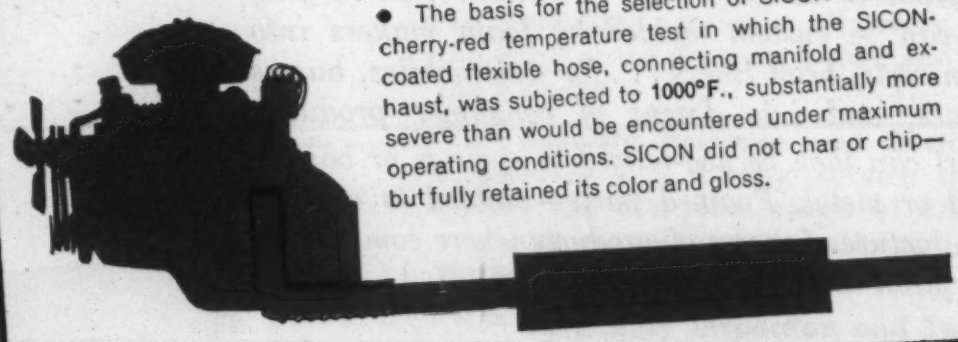
Where Creative Chemistry Works Wonders For You

For more information, turn to Reader Service Card, Circle No. 384

"Wrought from the finest materials in the world"

CONTINENTAL MARK II

Example: **SICON® Heat Resistant Finish**



● The basis for the selection of SICON was this cherry-red temperature test in which the SICON-coated flexible hose, connecting manifold and exhaust, was subjected to **1000°F.**, substantially more severe than would be encountered under maximum operating conditions. SICON did not char or chip—but fully retained its color and gloss.

● Only the finest in materials are good enough for the magnificent Continental Mark II. SICON not only resists high temperatures on the flexible hose connection—where the movable segments would quickly chip ordinary finishes—but also retains its rich color and gloss to assure fine appearance.

Wherever there is high temperature, wherever product *appearance* is as important as *protection* you need the tough film adhesion of SICON. You can specify SICON in black, aluminum—even in smart decorative colors. Write for SICON literature . . . today.

Sicon®

The Original Silicone Heat Resistant Finish

MIDLAND *Industrial Finishes Co.* Waukegan, Ill. Dept. K-1

ENAMELS • SYNTHETICS • LACQUERS • VARNISHES

OTHER NEW MATERIALS PRODUCTS

copper on both sides the standard ratio is 10-80-10. Other single and double clad ratios can be produced in 90-10, 70-30, 5-90-5 and 20-60-20.

Typical applications for the material are fuse clips, connectors, springs, and switch parts for rheostats, switches, relays and thermostats. In non-electrical applications such as pen and pencil clips, the copper layer provides a good base for electroplated finishes.

Plastic Insulation for Use to 1800 F

A plastic insulation made of asbestos, mineral wool and binders for use to 1800 F has been announced by *J. H. France Refractories Co.*, 1944 France Rd., Snow Shoe, Pa. The material, called Franco-Therm, can be applied around flanges, fittings and difficult shapes. It can be used on any hot or cold surface—brick, metal or tile. It is claimed to absorb hot or cold water without harm, and it resists boiling water.

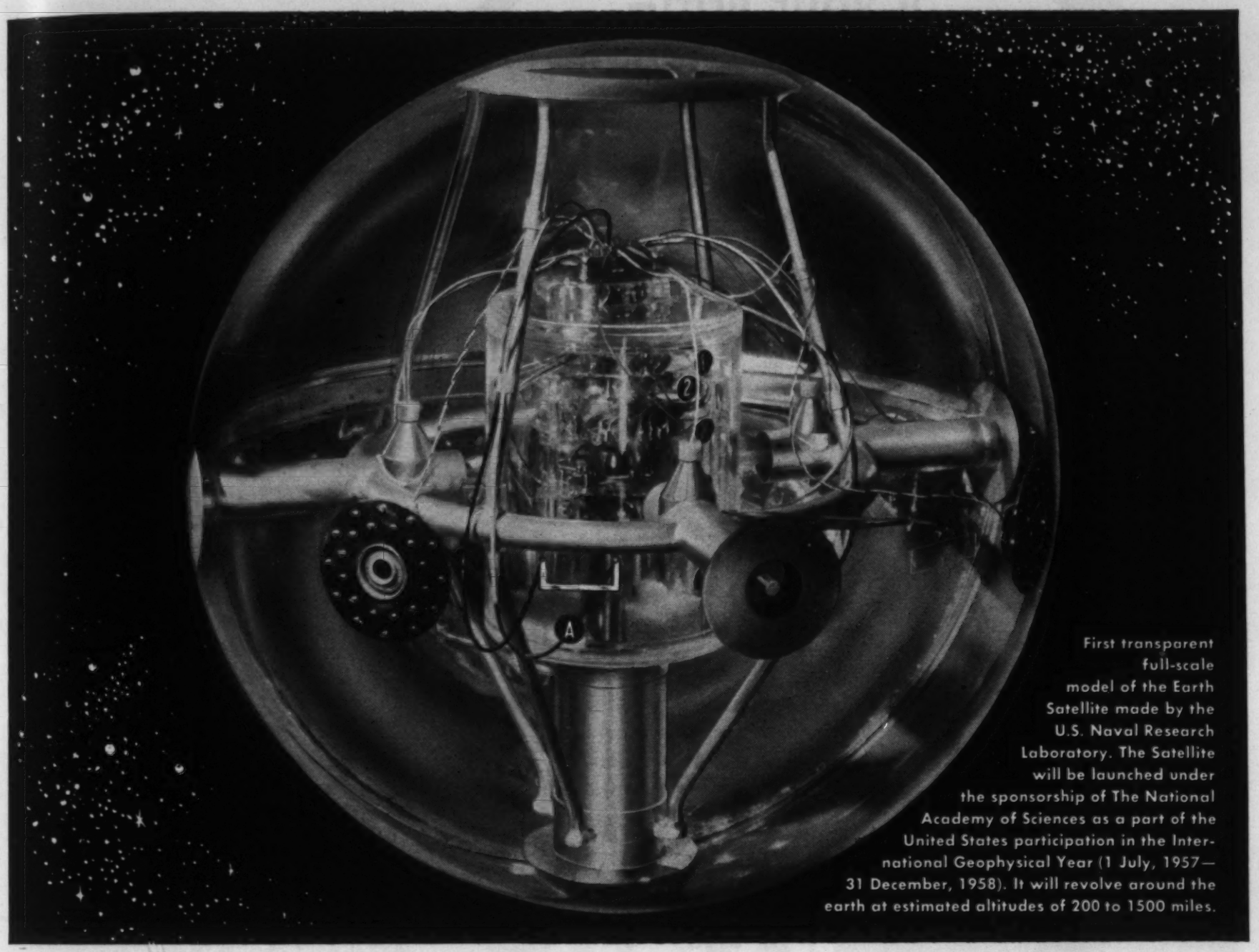
The insulation finds use around air ducts, boiler settings, burner casings, cookers, gas generators, heat exchangers, hot air lines, hot water heaters, incinerators and industrial furnaces and ovens. Coverage is 23.5 sq ft per in. thickness per 50 lb of dry material.

Silicone Foam Rubber Has Good Recovery

A silicone foam rubber, called Cohrfoam, has been developed by *Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn. The new foam rubber, with a specific gravity of 0.20 to 0.35, is lightweight and remains soft and resilient over a temperature range of —100 to 480 F. Because of its interconnecting cell structure, the material recovers shape instantly after being compressed

For more information, turn to Reader Service Card, Circle No. 461

DRIVER-HARRIS ALLOYS AT WORK IN PRODUCT ADVANCEMENT



First transparent full-scale model of the Earth Satellite made by the U.S. Naval Research Laboratory. The Satellite will be launched under the sponsorship of The National Academy of Sciences as a part of the United States participation in the International Geophysical Year (1 July, 1957—31 December, 1958). It will revolve around the earth at estimated altitudes of 200 to 1500 miles.

How measure the impact of micro-meteorites on the first "Earth Satellite"?

When physicists at the U.S. Naval Research Laboratory consider an instrument or a material to record accurately the secrets of outer space—it's not size alone that counts, but dependable, reliable precision.

The strip of "Nichrome"* evaporated on glass ("A" in the photo above) which may be fitted to the outer skin of the Satellite, measures only ¼" wide x 1½" long. Its thickness: 100 Angstrom units (1/10,000 mm). Its function: to measure the surface erosion caused by the impact of micro-meteorites. The resistance of the Nichrome ribbon increases as the film becomes pitted by meteor particles.

"Nichrome is being considered for making this gage," states the Naval Research Laboratory, "because it supplies electrical resistance in a desirable range; adheres satisfactorily to glass in thin film form; and has a very low thermal coefficient of resistance."

There'll be no one on hand, 300 miles out in space, to check on or supervise the performance of the Nichrome strip. Nichrome needs no one. It will do its job dependably there—just as it will in *your* electronic or electrical equipment, after it is in your customers' hands.

And remember, Nichrome is only one of the 132 special purpose alloys developed by Driver-Harris since 1899 for electrical heating, resistance, and electronic applications. Do you need a special alloy? Send us your specifications.

*T.M. Reg. U.S. Pat. Off.

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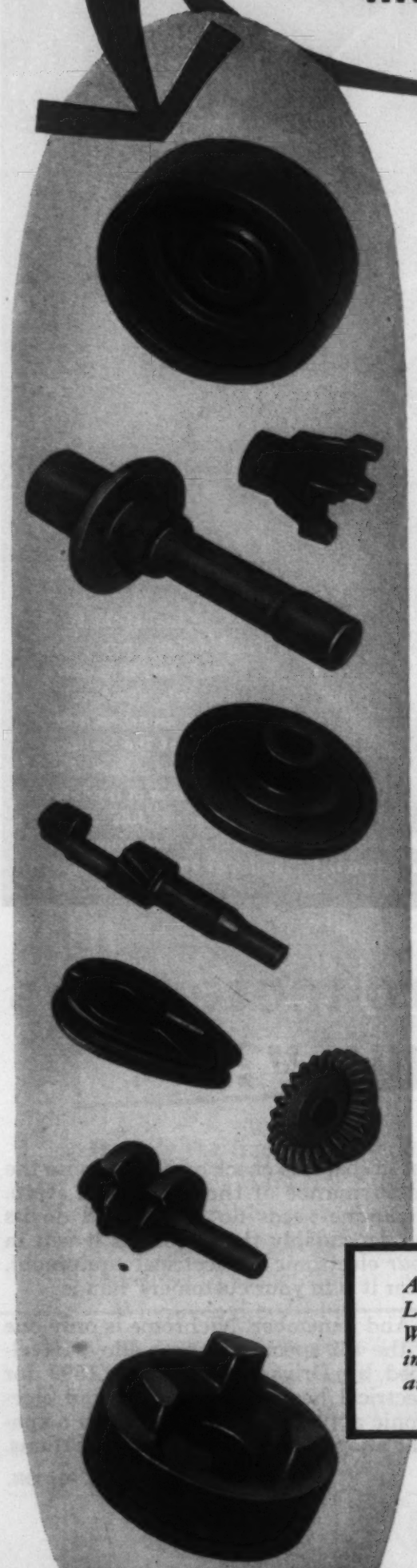
if your firm—
uses parts anything
—like these . . .



we'll show you
how to—

reduce your costs!

Through Albion's modern *resin shell* casting techniques, pearlitic and ferritic malleable irons may be cast to your specifications and tolerances with physical properties to suit your specific range of applications.

And more important, Albion's *resin shell molded* pearlitic and ferritic malleable iron castings combine the advantages of both castings and forgings. They're produced to extremely close dimensions to eliminate excess metal as well as machining or grinding operations; for greater production time, tool and labor savings.

Phone your Albion Malleable Iron Company representative today. He can show you how to save valuable time and dollars through Albion's modern casting techniques.

Albion's Research and Development Laboratory facilities are at your disposal. Whether you are designing new or reviewing present parts, Albion's engineers are anxious to assist you.

ALBION MALLEABLE IRON CO. ALBION MICHIGAN

For more information, turn to Reader Service Card, Circle No. 538

OTHER NEW MATERIALS PRODUCTS

for long periods at elevated temperatures.

The silicone foam rubber (see M&M June '56, p 169) can be molded into complex shapes and is reported to have found use as airframe seals where no other material has operated successfully. Other uses include sound and vibration packing, electrical and thermal insulation, and mechanical sealing where a large, light seal is needed.

The material, like other silicone rubbers, is said to be inert to ozone and weathering, nonsticking, noncorrosive, odorless and tasteless. It also has good electrical properties. In applications requiring good abrasion resistance the foam can be covered with Dacron fabric or Teflon film. The material will be offered in sheet form and as custom moldings up to 8 in. thick.

Extruded Acrylic Sheet Developed for Forming

An extruded acrylic sheet substantially lower in cost than cast sheet is now being offered in clear and standard colors by *Cadillac Plastic & Chemical Co.*, 15111 2nd St., Detroit 3, Mich.

Available in any quantity from one sheet up, the extruded sheet is reported to be free from extrusion lines and other marks or blemishes. The material may be vacuum or drape formed and has

***Typical parts** fabricated from both clear and colored extruded acrylic sheet.*

OFHC® COPPER

ONLY AMCO MAKES IT

And anodes made of OFHC copper are produced only by AMCO.

OFHC stands for **O**xygen **F**ree **H**igh **C**onductivity copper. OFHC copper is the only oxygen-excluded copper—it is not deoxidized copper.

Plating with OFHC Copper Anodes therefore means:

more usable copper per anode •
smoother finishes •
product uniformity •
no bags or diaphragms •

Technical assistance and additional information available upon request.

Metal Sales Department
THE AMERICAN METAL COMPANY, LTD.
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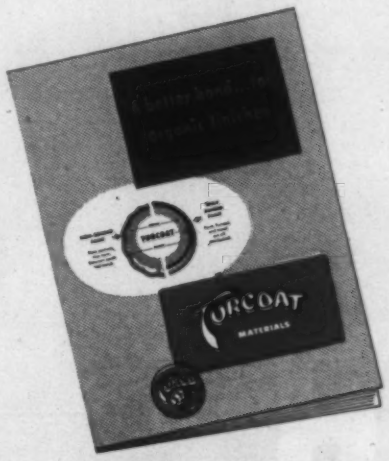
poor paint adhesion?



FREE MANUAL
shows how phosphating will solve your problems!

If poor paint adhesion is your problem, chances are you'll find the solution in the Turcoat Phosphating Manual. This booklet describes the complete Turcoat line, tells the full story of phosphating and includes a valuable "Phosphating Reference Chart," which quickly gives the answer to any paint adhesion problem.

If you are interested in permanent paint adhesion, write today for the Turcoat Manual. There is no cost or obligation.

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You will be assured of a *permanent paint seal,* simply by using Turcoat as a bond for organic finishing.

Please affix coupon to company letterhead
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Please send me a copy of the Turcoat Manual without cost or obligation.

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Title_____ MM

For more information, turn to Reader Service Card, Circle No. 416

OTHER NEW MATERIALS PRODUCTS

minimum shrinkage at forming heats. It is available in standard 0.060-, 0.080-, 0.100- and 0.125-in. thicknesses, in 49 in. widths and in lengths as desired. Other sizes are available on request.

Applications of the extruded acrylic sheet include light fixtures, models and training aids, templates, tank liners, protective covers, signs, displays, laminations, dials, inspection windows, nameplates, emblems and medallions.

Ultra-Thin Copper Strip

American Silver Co., 36-07 Prince St., Flushing 54, N. Y., is now supplying copper strip in thicknesses down to 0.00025 in. with tolerances of ±0.00005 in. Material is available in widths from ¼ to 5 in.

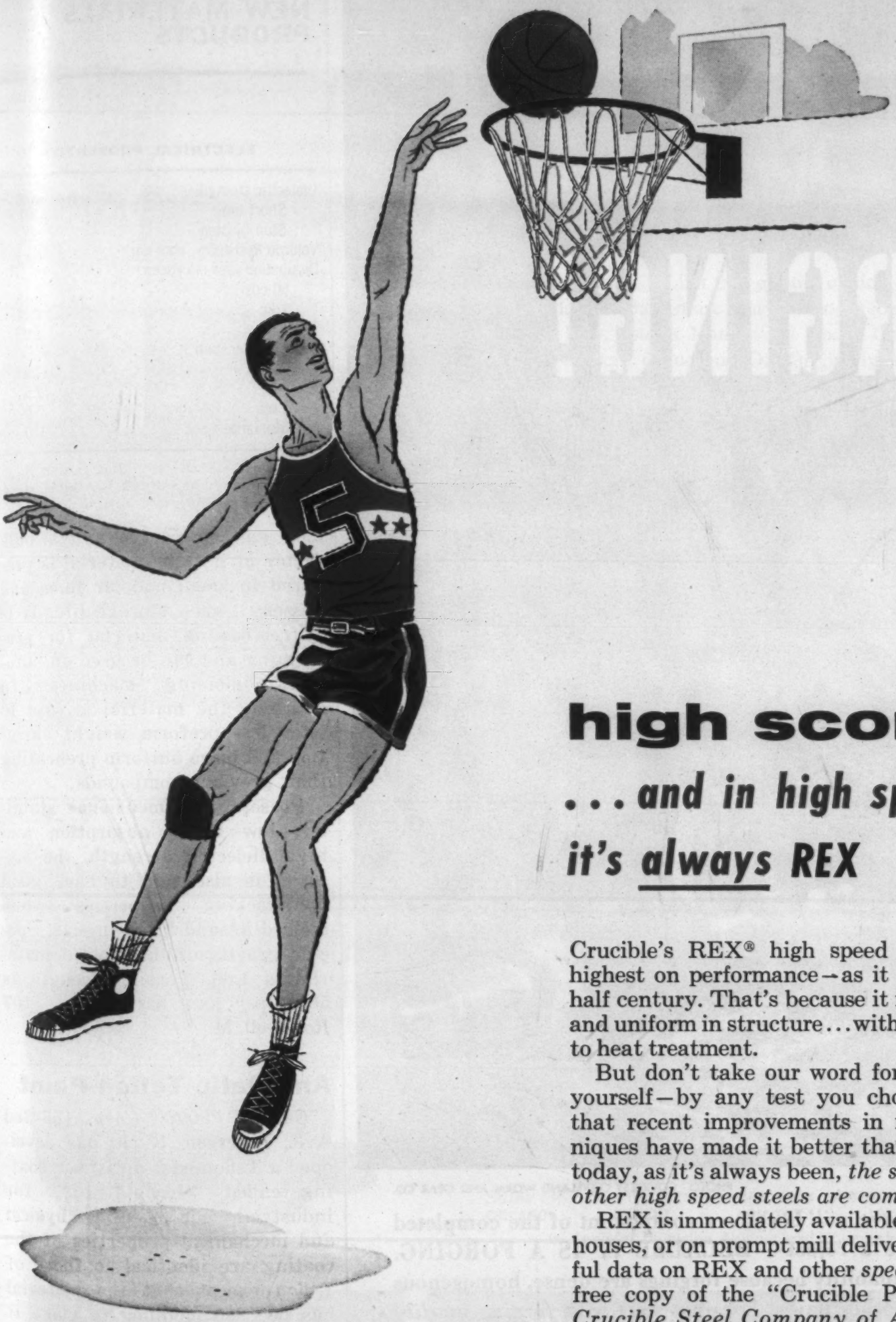
The ultra-thin metal, one-twelfth the thickness of a human hair, permits the design of miniaturized transformers and other electronic components by the substitution of tape wound wafer-type copper coils for coils formerly made from magnet wire. The wafer design provides uniform flat coils, each with self-contained terminals.

Other uses for the material include small solenoids for automatic transmissions in automobiles, and pulse transformers and solenoids for traveling wave tubes.

Phenolic Compound Is Arc Resistant

An arc resistant molding compound, introduced by *Durez Plastics Div., Hooker Electrochemical Co.,* North Tonawanda, N. Y., consists of a two-step mineral- and flock-filled phenolic resin. Called "Durez 18001 Black," it is designed to provide arc resistance of 120 sec plus greater impact strength than previous compounds.

With an apparent density of



high scorer

...and in high speed steels, it's *always* REX

Crucible's REX® high speed steel always scores highest on performance—as it has for more than a half century. That's because it is consistently sound and uniform in structure...with dependable response to heat treatment.

But don't take our word for it. Check REX for yourself—by any test you choose. You'll discover that recent improvements in manufacturing techniques have made it better than ever—why REX is today, as it's always been, *the standard by which all other high speed steels are compared!*

REX is immediately available at all Crucible warehouses, or on prompt mill delivery. For a list of helpful data on REX and other *special steels*, write for a free copy of the "Crucible Publication Catalog." *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

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For more information, turn to Reader Service Card, Circle No. 457

STAY OUT OF TROUBLE WITH A

FORGING!

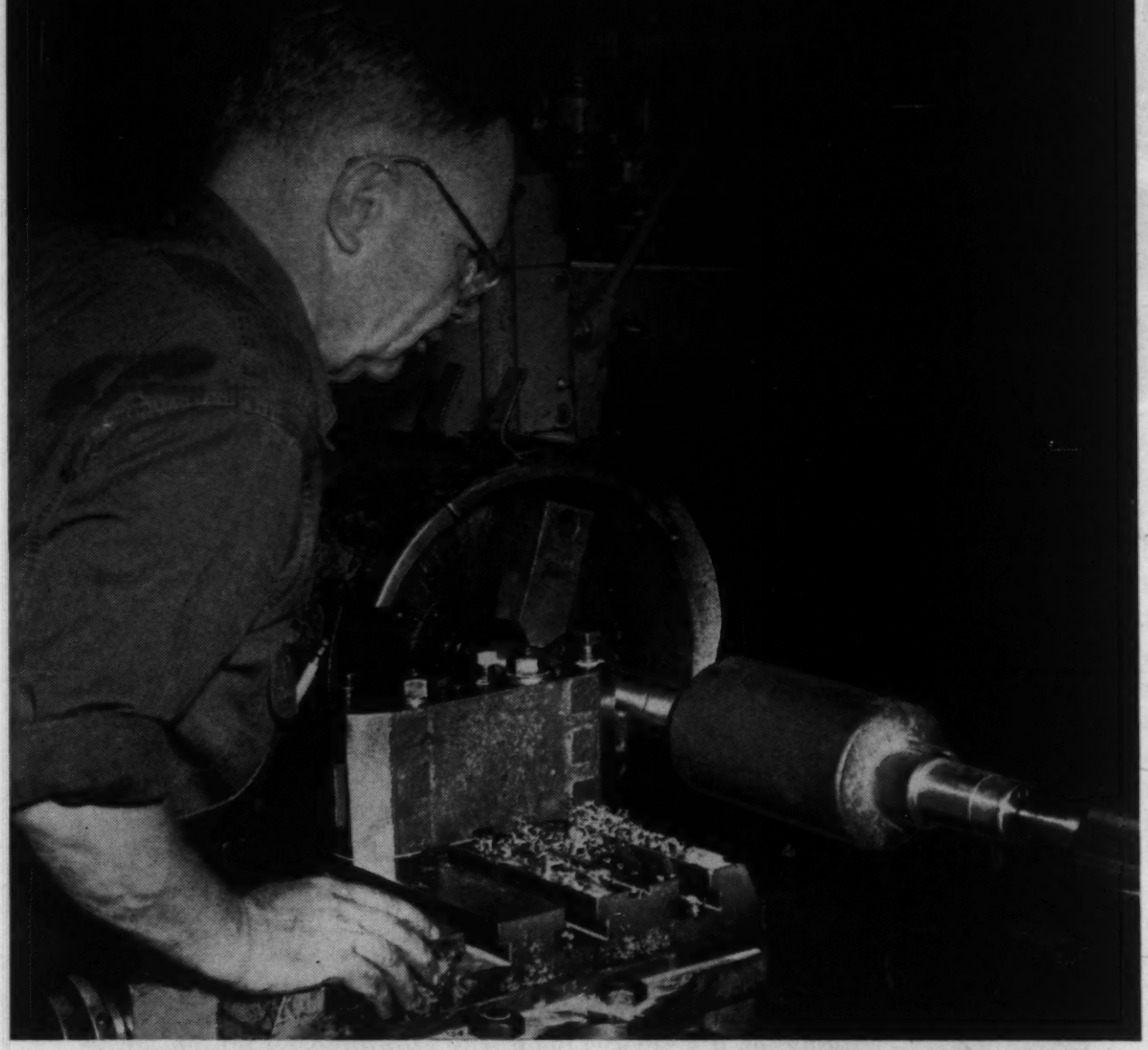


PHOTO - COURTESY CLEVELAND WORM AND GEAR CO.

The part illustrated above *will* become a component of the completed product — will *not* become a reject — BECAUSE IT IS A FORGING.

You get effective machinability because forgings are dense, homogenous metal, free of porosity and other flaws. Forgings start with *forging quality metal* which is improved by the forging process. This fact also offers advantages in heat treating and welding.

If you are experiencing a costly reject rate, find out how *forgings will help you.* Call in a forging engineer, and also send for the booklets offered below to learn the economies that can be gained by the use of forgings in your product.

Reduce your cost by using forgings. Send for booklets, ☐ "What is a Forging?" and ☐ "Management Guide to the Use of Forgings."

closed-die **forgings** for metal you can trust

DROP FORGING ASSOCIATION

Dept. M. 419 S. Walnut St., Lansing, Mich.

Symbolic emblem of the Drop Forging Association

OTHER NEW MATERIALS PRODUCTS

ELECTRICAL PROPERTIES

Dielectric strength[a], v/mil:	
Short-time	400
Step-by-step	300
Volume Resistivity, ohm-cm[b]	1×10^{12}
Dissipation (power) Factor[b]:	
60 cps	0.14
1 kc	0.14
1 mc	0 05
Dielectric Constant:[b]	
60 cps	10.0
1 kc	7.5
1 mc	5.0
Arc Resistance[c], sec	120

Conditions: [a]48 hr, 50% R.H. at 73 F. [b]48 hr, at 122 F.—tested at rm temp. [c]50% R.H. at 73 F.

0.65 gm per cu cm and a bulk factor of 2.4, the material is prepared in small nodular form and possesses good storage life. It is a free-flowing material for preforming and can be used on automatic molding machines. In addition, the material is said to offer less preform weight variation and more uniform preheating than previous compounds.

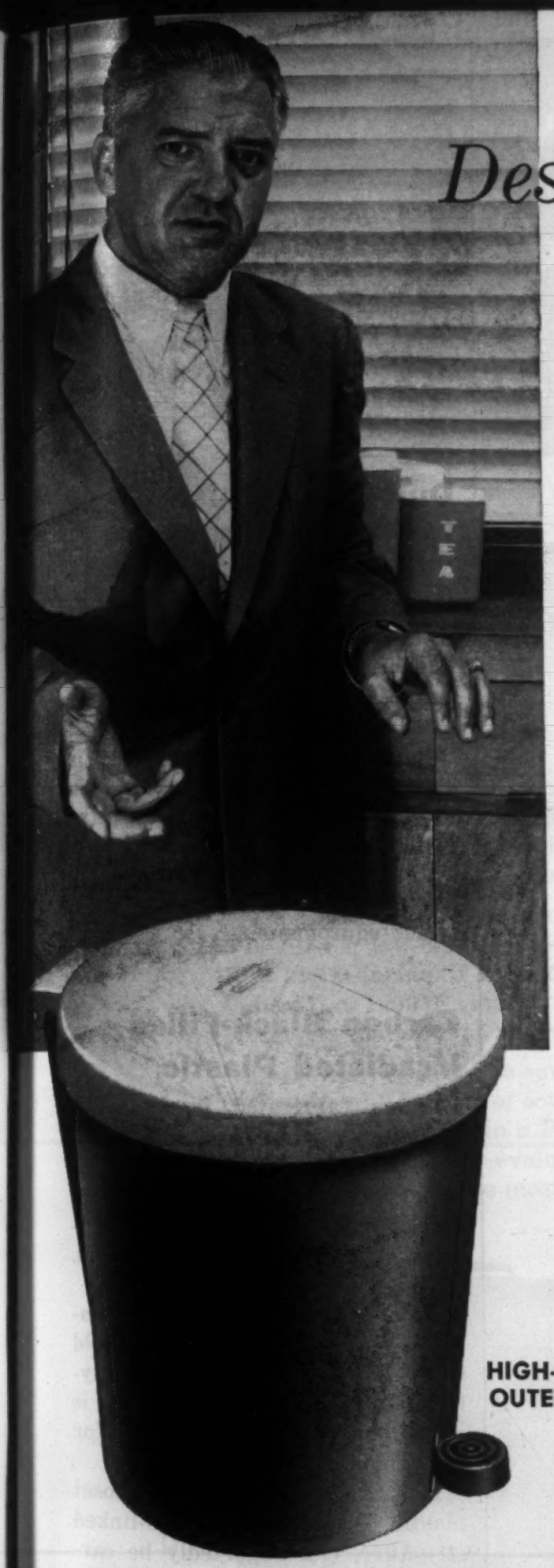
Possessing dimensional stability, low water absorption and high dielectric strength, the material is also said to have good non-cracking properties when molded around large inserts. Specific gravity of the molded material is 1.66. Tensile strength is 5000 psi and hardness is 107 Rockwell M.

Antistatic Teflon Paint

General Plastics Corp., 165 3rd Ave., Paterson, N. J., has developed a Teflon-base antistatic coating called "Gencote 108" for industrial equipment. Physical and mechanical properties of the coating are identical to those of Teflon except that the material has been so modified to make it conductive. The coating provides a dry-lubricated, chemically inert surface that is antistatic.

Electrical resistance across the coating, when applied in a 4-mil film, is approximately one ohm per ½ sq in. Coatings of ½ to 10 mils can be applied to any metal or other material that can withstand the 700 F temperature re-

For more information, Circle No. 567



HIGH-IMPACT OUTER SHELL

Designer Nathan Roop talks plastics:

"In the early days, we felt that plastics could be used to create anything at all. Today, we have more practical knowledge of what we can do best . . . and how," states Nathan W. Roop, Chief Designer, Columbus Plastics Products, Columbus, O. "Originally, many people were rather unfair to plastics. Metal dents, and glass breaks . . . yet the public, accustomed to this over the years, has learned to accept the limitations innate in certain materials. Plastics, on the other hand, were expected to be absolutely perfect! This means that we have had to achieve more within our marketable forms than manufacturers in other materials. The fact that we have done so, despite unreasonable expectations, is proven by the industry-wide expansion that has taken place."

Mr. Roop designed the Lustro-Ware Step-On Can shown here. This item won the "Best of Competition" award in the 1956 Koppers Annual Design Competition. In the past seventeen years, he has played a major role in designing and producing nearly three thousand different molded plastic parts.

"One of the factors responsible for advances in the plastics field can be traced to demands by housewives for particular items." Roop felt that, "Another factor is the tremendous advances made in composition of plastic material. Once limited to acetate and butyrate, we now have high-impact styrene, polyethylene, and other compounds which have enabled us to turn out a wider range of superior products."

Koppers furnishes the plastics industry with these four fine plastics: DYLAN® polyethylene, SUPER DYLAN* polyethylene, DYLENE® polystyrene and DYLITE® expandable polystyrene. For more information on any of these plastics, write to Koppers Company, Inc., Chemical Division, Dept. MM-116, Pittsburgh 19, Pennsylvania.

**Koppers Trademark*

For more information, turn to Reader Service Card, Circle No. 533

KOPPERS

KOPPERS PLASTICS

Sales Offices: PITTSBURGH • NEW YORK • BOSTON • PHILADELPHIA • ATLANTA
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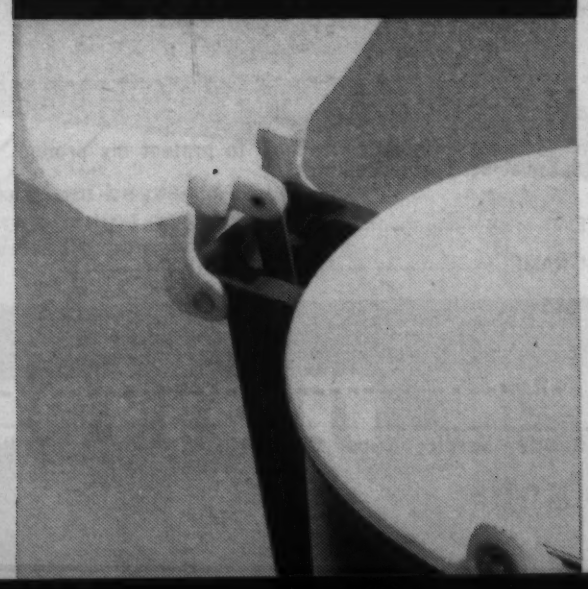
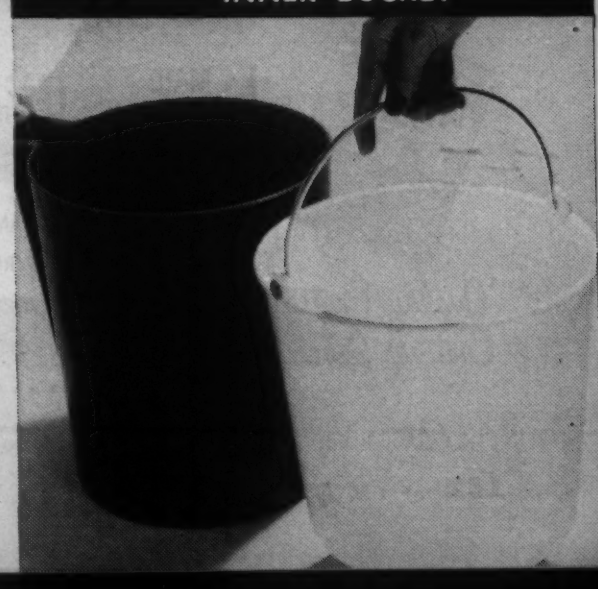
In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

STEP-ON, LID-RAISER

STAY-OPEN HINGE



SEAMLESS POLYETHYLENE INNER BUCKET



Buildings of Today and Tomorrow...

Protected With SPRAYLAT Strippable Coatings!

Now... window frames, polished or painted metal doors, door bucks, ornamental metal, tile and marble units, and other component parts for new buildings are being protected with SPRAYLAT* and COVERLAC* Strippable Coatings.

The various products are spray coated by the manufacturer in his plant, for protection during fabrication, shipment, installation and construction. When the building is completed, SPRAYLAT'S tough, pliable coatings are easily "peeled off" leaving surfaces factory-fresh... free from foreign material, scratches and other injuries. Hours of costly refinishing are thereby avoided.

From start to finish... in every phase of manufacture... whether the surface is enamel, lacquer, metal, plastic, glass or marble, SPRAYLAT CORPORATION has a specialized compound for every requirement.

Remember... it is cheaper to protect than to refinish.

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COVERLAC-Trademark-Reg. U. S. Pat. Office

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'Quality Protective Strippable Coatings Since 1937'

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SPRAYLAT CORP., One Park Ave., New York 1, N. Y.
Please send me information on how to protect my product with Spraylat Strippable Coatings.

NAME:..... POSITION:.....
FIRM NAME:..... PRODUCT:.....
ADDRESS:.....
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For more information, turn to Reader Service Card, Circle No. 504

OTHER NEW MATERIALS PRODUCTS

quired for the baking process. The coating can be used to provide an electrically conductive surface for glass, ceramics and porcelain.

Dull Black Finish for Die Castings

Conversion Chemical Corp., Rockville, Conn., has announced the development of a metal finish known as Kenvert No. 11-B which can be applied to zinc or cadmium die castings. The coating is an intense, dull black finish which is said to provide good corrosion protection when applied over the appropriate conversion coating.

The process can be conducted at room temperature without exhaust equipment.

Carbon Black-Filled Irradiated Plastic

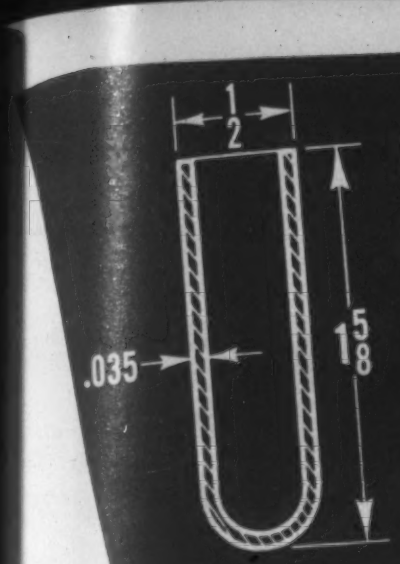
Parts fabricated from irradiated polyethylene and filled with carbon black are being produced experimentally by the *Chemical Development Dept., General Electric Co.*, 1 Plastics Ave., Pittsfield, Mass.

Called Vulkene 107-E, the material is said to have a yield strength double that of polyethylene, and creep deformation is only about 10% of the value for polyethylene.

The black, semirigid, thermoset plastic, because of its cross-linked structure, can reportedly be carried to its decomposition temperature without melting. At 300 F it retains a tensile strength of 500 psi. Continuing laboratory tests indicate that the resistance of the material to chemical attack is superior to that of conventional (low density) polyethylenes.

Though stiffer than polyethylene, the reinforced material is flexible and does not exhibit the brittleness, low tear strength and low elongation normally associated with highly filled formula-

For more information, Circle No. 369



How to fully anneal this drawn copper shell . . . in large quantities . . . in short time . . . and get exact uniformity!

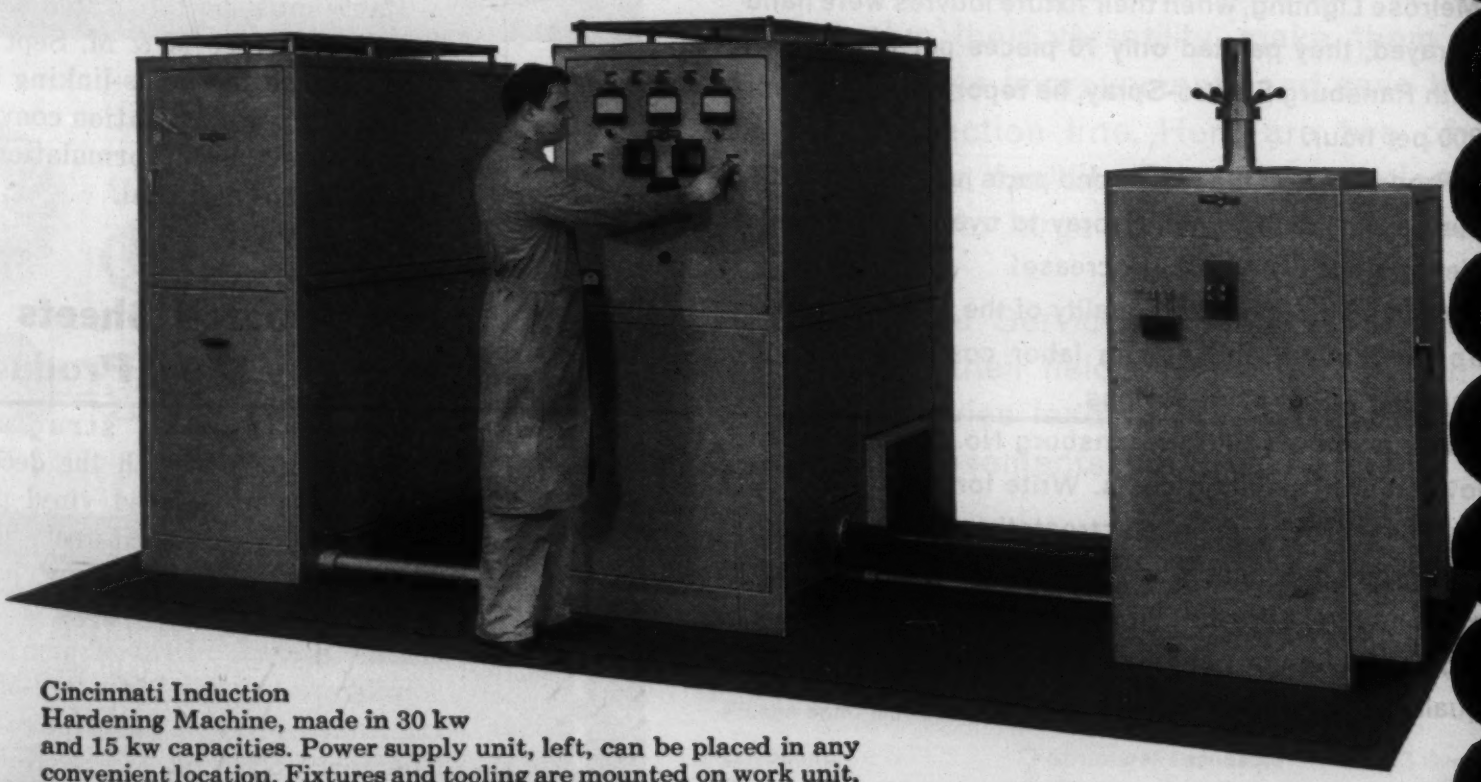
Cincinnati Inductron*

does it in 1.7 seconds per piece

Work hardening from the drawing operation interfered with subsequent operations, so these shells had to be fully annealed. Furnace heating in mass did not produce the high uniformity of anneal required, and the pace of production prohibited an increase in the heating time.

The problem was presented to Cincinnati heat treating specialists, and they devised a low-cost method of heating the parts, individually, in a new 15 kw *Cincinnati Induction Hardening Machine. A full anneal was produced at 1200 °F. in 1.7 seconds. An automatic work handling system delivers the parts at the required rate.

If you have a selective surface hardening or part heating problem, talk to Cincinnati—*builders of both Flamatic flame hardening and induction hardening equipment*. Call in a Process Machinery Division field engineer. He is ideally equipped to evaluate your needs and give you unbiased recommendations as to the most economical and efficient method.



Cincinnati Induction Hardening Machine, made in 30 kw and 15 kw capacities. Power supply unit, left, can be placed in any convenient location. Fixtures and tooling are mounted on work unit, right. Bulletin M-1938 gives full details. Write for your copy.

CINCINNATI **induction** *hardening*

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.

What d'ya mean . . .

You're too little to use RANSBURG Electrostatic Spray Painting?

If your production justifies conveyorized painting, chances are RANSBURG NO. 2 PROCESS can do YOUR painting job better . . . at less cost.

RANSBURG NO. 2 PROCESS *accounts for a 50% savings in paint costs in finishing fluorescent lighting fixture parts for* MELROSE LIGHTING COMPANY, *Philadelphia. Melrose is a small plant employing only 25 people.*

Not only big industrial manufacturers like G. E. . . . Whirlpool-Seeger . . . Westinghouse and Republic Steel, but little plants, too, are using RANSBURG NO. 2 PROCESS in their finishing departments to help keep mounting manufacturing costs in line.

A typical example is Melrose Lighting Company, Philadelphia. They make industrial fluorescent lighting fixtures and employ only 25 people.

Formerly, according to F. Homer Hagaman, owner Melrose Lighting, when their fixture louvres were hand sprayed, they painted only 70 pieces per hour. Now, with Ransburg Electro-Spray, he reports they get over 200 per hour.

Production on the fixture end parts jumped from 400 pieces per hour by hand spray to over 2000 an hour electrostatically—a 400% increase!

Along with improving quality of the work, stepping up production, and cutting labor costs, Melrose is enjoying a 50% paint savings.

Let us show you how Ransburg No. 2 Process can lower YOUR painting costs. Write for our new No. 2 Process brochure on electrostatic spray painting. Numerous production-line examples show how other manufacturers are cutting finishing costs . . . increasing production . . . and improving the uniformity and quality of their work with Ransburg equipment.

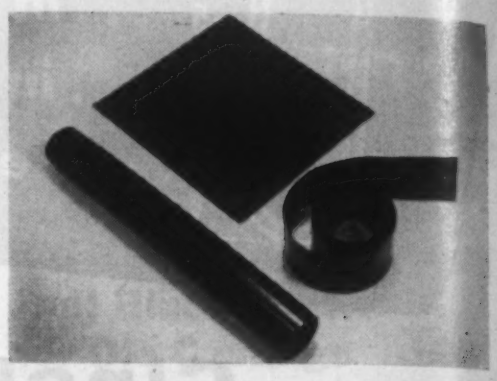
Ransburg **ELECTRO-COATING CORP.**

Indianapolis 7, Indiana

RANSBURG

For more information, turn to Reader Service Card, Circle No. 564

OTHER NEW MATERIALS PRODUCTS



Available forms *of irradiated polyethylene reinforced with carbon black include sheet stock, extruded tubing and electrical tape.*

tions. Specific gravity of the carbon black-filled polyethylene is 1.05 and tensile strength is 2400 to 2600 psi. Compared with low density polyethylene, elongation is somewhat reduced, whereas hardness and tear strength are increased.

Because of its high carbon-black loading, the irradiated polyethylene is electrically conductive. GE reports it is presently test marketing a modification of the material as semiconductor tape in shielded power cables. In tape form, the material is sold under the trademark, Irrathene.

Parts must be fabricated before irradiation (see M & M, Sept '54, p 91), since the cross-linking that occurs during irradiation converts the thermoplastic formulation to an infusable material.

Vinyl-Coated Sheets Made by Steel Producer

Combining the structural strength of steel with the decorative effects of colored vinyl plastic, a cold-reduced steel sheet coated with vinyl is now being produced at *U. S. Steel Corp., Irvin Works,* Dravosburg, Pa. Similar to the Marvinol-Metal Laminate developed by Naugatuck Chemical Div. of U. S. Rubber Co. (M&M, Sept '53, p. 94), the product is available in 18- to 28-gage sheets 24 to 52 in. wide.

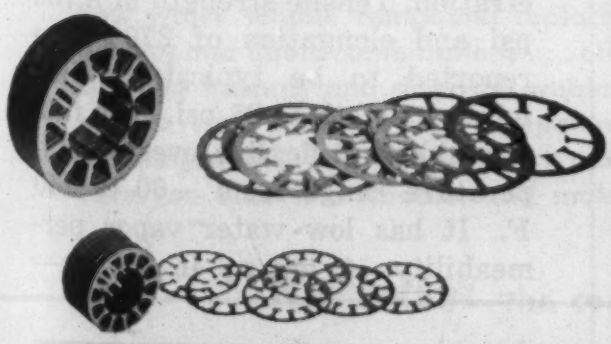
The vinyl coating has high abrasion resistance and good di-

For more information, Circle No. 584 ➤

Araldite® First in Epoxies

Precision... Large Scale!
Araldite Epoxy Resins adapt themselves to large scale precision design as illustrated in this 14 foot aluminum reflector. The skin, made with Araldite and glass cloth, is then bonded with Araldite Epoxy to aluminum and honeycomb to complete the structure.
Formulator: Emerson & Cuming, Inc.
Customer: I.T.E. Circuit Breaker Co.

Precision... In Miniature!
High bond strength and excellent electrical properties of Araldite Epoxy Resins make possible the design and production of this chatter-less stator.
Formulator: Rubber & Asbestos Corp.
Customer: Kollsman Instrument Company.



Ciba Araldite Epoxy Resins come with the assurance that they have met not only our rigid PRODUCTION qualfiy control standards but the specific APPLICATIONAL requirements of the user as well.

Ciba produces basic resins only, to be formulated for intermediate and end uses.

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OTHER NEW MATERIALS PRODUCTS

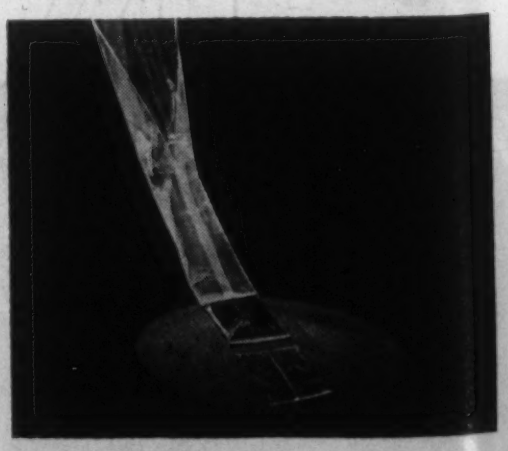
electric properties. It is resistant to humidity and many chemicals and possesses sound-deadening characteristics for acoustical applications. The material, being offered for sale on a developmental basis, is designed for use in refrigerators, radio and television cabinets, automobile bodies, office furniture and other products where appearance and long service are important.

Clear Polyester Film Sealable on Both Sides

A new variation of its basic heat sealable polyester film has been announced by *Minnesota Mining Mfg. Co.*, 900 Fauquier St., St. Paul 6, Minn. The clear film, called Scotchpak B, is heat sealable on both sides, enabling it to be combined into tubular forms.

The film—durable, nontoxic and chemically resistant—is designed for packaging such dissimilar items as acids, precision metal parts, lubricating oils and solvents.

The film is said to have good dielectric strength and good resistance to fungus and insect penetration. Tensile strength of 8,700 psi and elongation of 270% are reported to be typical. Mullen burst strength is 25 psi. The film is stable and flexible over a temperature range from —60 to 240 F. It has low water vapor permeability—4 gm/sq in./24 hr—



***Heat sealable** polyester film is used for packaging items.*

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Northwest 449 is really big news! This "complete" new water soluble compound replaces complicated powder and liquid combinations . . . eliminates metal cleaning hazards and disposal problems. It's harmless to rack coating and equipment and makes handling and control simple, easy and SAFE. It will save you time and trouble, and make you money.

449 is an unusually efficient soak cleaner, specially developed for preparing non-ferrous metallic surfaces for plating and finishing operations. 449 has unusually long bath life and wide application range . . . costs no more than ordinary cleaners.

Get our expert analysis of YOUR job by calling or wiring us today.

Remember—the cost per finished piece is the true cost of your cleaner

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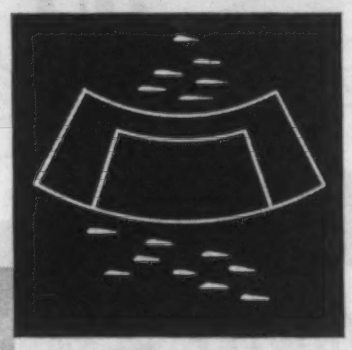
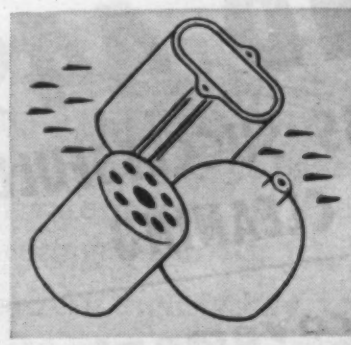
STACKPOLE
CARBON-GRAPHITE *Materials and Components*

Solve problems of friction, temperature, corrosion, arcing . . . and many others



LONG-WEAR FRICTION SEGMENTS

As a brake material, or in friction drives working against steel, Stackpole friction segments provide maximum life and efficiency—even under pressure changes and elevated temperatures.



ELECTRONIC TUBE ANODES

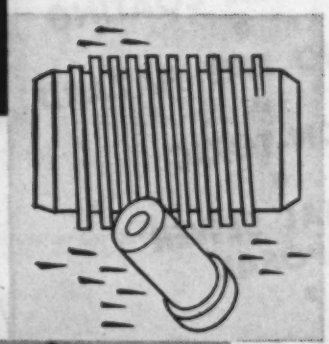
Non-warping, long-life Stackpole anodes assure lower temperature operation, uniform characteristics and important cost savings for electronic tubes of many different types.

NON-WELDING or FILMING ARC-RESISTANT CONTACTS

Stackpole silver plus refractory material contacts spell top efficiency in many electrical applications where ordinary contacts cause trouble because of arcing, welding or filming. Send details of application for recommendation.

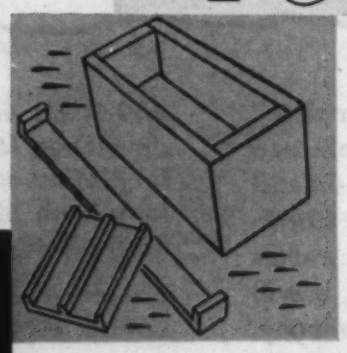
LOW-FRICTION BEARINGS

Stackpole carbon-graphite bearings are readily formed to close tolerances. Composition and shape can readily be designed for maximum efficiency on specific applications. New high temperature types now available.



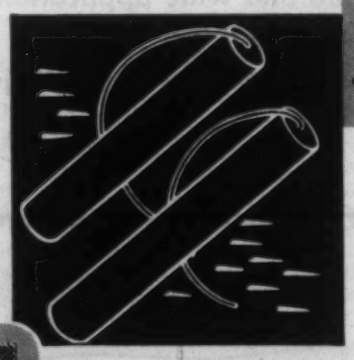
BRAZING BOATS *and* TRAYS

Practically any shape or size. Withstand extreme thermal shock . . . permit quick cooling. Alloys do not stick to trays in brazing.



BETTER RUST PROTECTION

For pipe lines, marine structures, ship hulls, tanks, structural footings . . . and other buried or immersed metal objects. Stackpole Cathodic Protection Ground Rods can be obtained from Corrosion Control Inc., Tulsa, Okla.



STACKPOLE CARBON COMPANY
St. Marys, Pa.

OTHER STACKPOLE PRODUCTS INCLUDE: BRUSHES for all rotating electrical equipment • metal powder ELECTRICAL CONTACTS • CARBON DISCS (piles) • CHEMICAL ANODES • SEAL RINGS • CLUTCH RINGS • PUMP VANES • MOLDS and DIES • WELDING CARBONS RESISTANCE WELDING and BRAZING TIPS • POROUS CARBON • PURE CARBON SPECTROGRAPHITE • ELECTRIC FURNACE HEATING ELEMENTS • WATER HEATER and PASTEURIZATION ELECTRODES . . . and many more.

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OTHER NEW MATERIALS PRODUCTS

and high dimensional stability, and it is impervious to odors.

Scotchpak B is currently available in 2½-mil gage only. It is supplied in standard roll length of 700 and 1000 yd and widths up to 19½ in.

Colored Aluminum Tube

Color anodized aluminum tubing has been introduced by *Reynolds Metals Co., Industrial Parts Div.*, Louisville, Ky. The tubing is available in natural aluminum, gold and blue. Each color can be obtained with a satin, semibright or bright-with-high-luster finish. The tubing is available in ¾-, ⅞-, and 1-in. dia in standard wall thicknesses.

Brass Electroplates of Reproducible Colors

Control of brass plating color by means of a new plating process has been developed by *Albany Plating Co.*, 464 W. 33rd St., Chicago 16, Ill. Known as "Albanizing," the new process eliminates matching of sets or lots to obtain a uniform color of the finish. It is said that exact color control can be maintained on parts plated at different times, thus permitting complete interchangeability of parts.

The new process is effective on all types of metals. Products up to 33 in. square can be plated with a variety of brass finishes, including gold and lemon yellow in bright reflective, scratch brush, dull, satin and other effects.

Copper Dispersion for Printed Circuits

A colloidal dispersion of metallic copper in a lacquer solution has been introduced by *Acheson Colloids Co.*, Port Huron, Mich. The material, having a shelf life of about 6 mo, has a total solids content of 66% by weight and a

density of 14.5 lb per gal. Covering power is approximately 45 sq ft per lb.

The dispersion, known as 'dag' No. 235, is said to be cheaper than silver paint and is more easily applied than copper foil which, in the production of printed circuits, has to be laminated onto a plastic base and etched away after the circuit has been printed.

It is said to provide a highly conductive surface coating for nonconductors and may be used for components of radar equipment, hearing aids and electronic measuring devices.

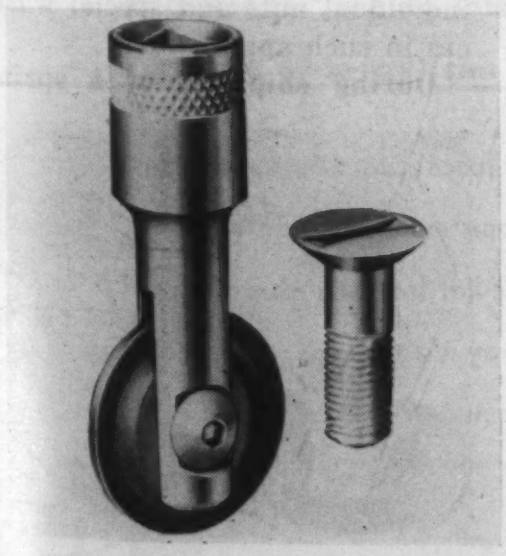
With a flash point of 21 F, the metallic copper dispersion air-dries within a few minutes. Adhesion may be improved by mechanical pre-treatment (sandblasting, etching, etc.) when necessary. Dip coating is not recommended. Application may be by spray or brush.

New Locknuts, Bolts and Other Fasteners

Recent developments in fasteners include two washer-faced locknuts and a bolt having a new recessed head design.

1. Recess bolt

Pheoll Mfg. Co., Aviation Div., 5708 Roosevelt Rd., Chicago 50, Ill., has announced a new type of recess design for its line of screws, bolts, blind bolts, cowl



***Bolt** of new recess design is shown with driver.*

For more information, Circle No. 595

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Nobody could expect a busy design engineer to keep up with all properties of all thermoplastics. That's Gering's job—and we offer highly practical advice on thermoplastics for your specific application. Also ideas on possible design modifications to cut cost or simplify assembly. This is only *part* of Gering's complete engineering and design service—all under one roof...all under one responsibility backed by Gering's knowledge resulting from over thirty years experience of producing high quality plastics.

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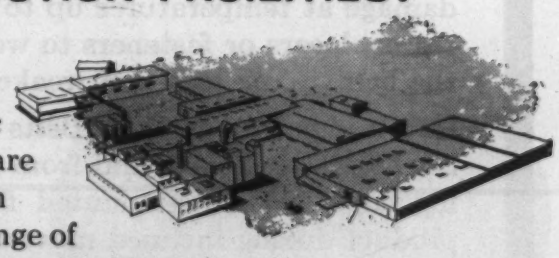

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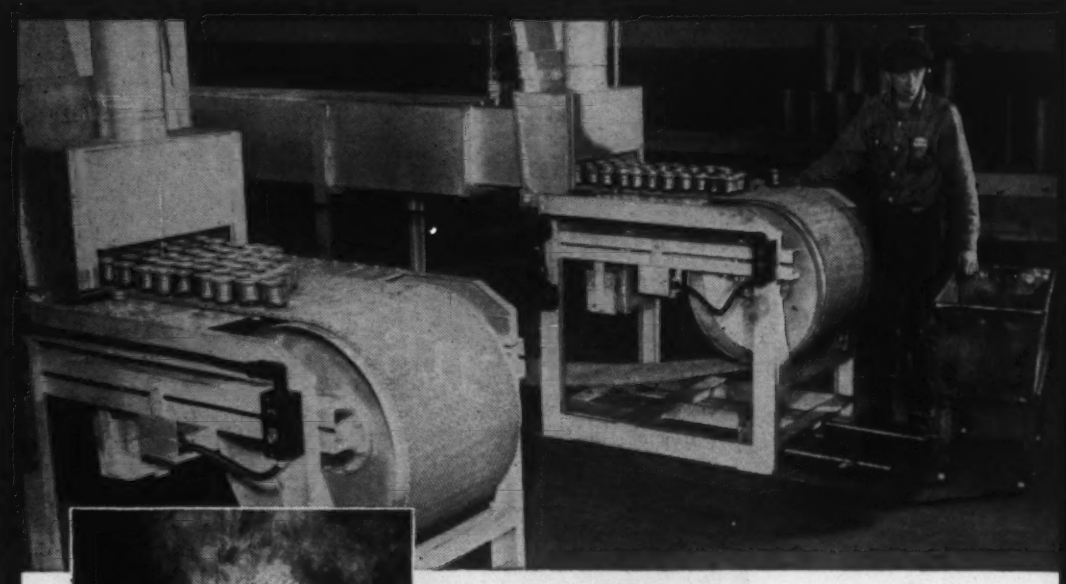
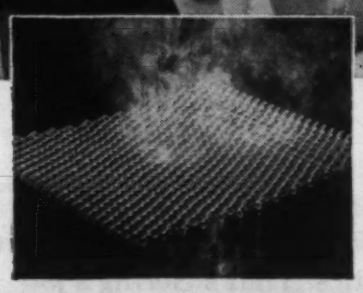
Cambridge

WOVEN WIRE CONVEYOR BELTS take the "hot spots" out of ANNEALING & BRAZING





FREE CIRCULATION of heat and gases through the all-metal belt and around the work permits continuous, uniform heating and cooling as work moves through your plant.

By combining controlled movement with free circulation of process atmospheres, Cambridge Woven Wire Conveyor Belts eliminate batch annealing and brazing. There is no formation of "hot spots" which produce local stresses. Continuous, belt-to-belt flow through subsequent quenching and washing operations as well as heating, cuts costs and provides fast, uniform production.

Not only does the open mesh construction provide free circulation of gases . . . it also permits rapid drainage of process solutions. The all-metal belt is corrosion resistant and impervious to damage at temperatures up to 2100°F. Cambridge belts have no seams, lacers or fasteners to wear more rapidly than the body of the belt . . . no localized weakening.

Cambridge Woven Wire Belts for heat treating are made in any size, mesh or weave, and from any metal or alloy. Special retaining edges or cross-mounted flights are available to hold your product during inclined movement.

Call in your CAMBRIDGE FIELD ENGINEER to discuss how you can eliminate batch handling from your heat treating. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for your copy of Special Report, "6 Ways to Increase Heat Treating Production" and 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department A, Cambridge 11, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

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OTHER NEW MATERIALS PRODUCTS

fasteners and other turning types of fasteners. It is claimed that the new design, called Hi-Torque, makes possible torquing values of at least two times torque requirements for all types and sizes.

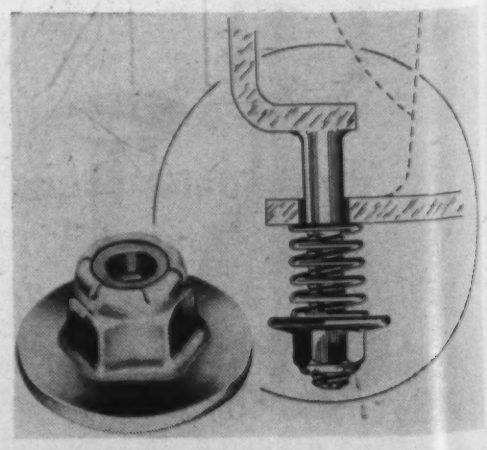
Featuring a recess with an accurate slot undercut on both sides and with driving surfaces parallel, the fastener employs a 360-deg driving blade. These features result in full bearing thrust of the driving blade against the driving surfaces, elimination of the camming action which tends to force the blade out of the slot, and longer driving blade life.

The fastener can be driven from either a horizontal or vertical position or from any angle by use of a universal joint. It is now available and used as National Aircraft Standard High Torque bolts 583 through 590. Special sizes are available on request and all types and sizes are available in such materials as alloy and stainless steels and titanium.

2. Self-locking nut

Designed with a large washer-type seat for fastening applications involving spring tension, such as compressor motor mountings in refrigerators, a new flanged, hexagonal, self-locking nut has been developed by *Elastic Stop Nut Corp. of America*, Union, N.J. The large built-in bearing area of the steel nut, called Esna Type 1994, eliminates the need of individual nuts and special washers in such applications.

During shipment of a spring



***Spring mounted** units can use this self-locking nut.*

HIDDEN flaws in your products need detecting?

Every day brings new inspection problems to Picker for possible solution. More often than not, radiography (or fluoroscopy) can help. *Here's a typical week's score . . .*

PROBLEM	SOLVED
glass splinters in some candy bars	✓
solder invasion of a precision resistor	✓
bubbles in glass containers	difficult
poor bond in ceramic insulators	✓
failures in adhesives	✓
knives in crude rubber "biscuits"	maybe
stringers in a highly-stressed lock nut	✓
clearances in a miniaturized amplifier	✓
solder tinning on a thin connecting lug	no
porosities in a new type of false tooth	✓
welds in bandsaw blades	✓

Makes no difference *what* you make or buy or sell . . . if it needs "seeing into" for quality control, radiography (gamma or x-ray) can probably profit you.

Talk it over with your local Picker representative * or write us outlining your problem and, if possible, sending typical samples. We'll make tests and tell you frankly whether radiography holds any promise for you. ***Costs you nothing to find out . . . maybe it's costing you a great deal right now NOT TO.***

** There's probably a Picker district office near you (see local 'phone book).*

Picker x-ray

PICKER X-RAY CORPORATION
25 South Broadway, White Plains, N. Y.

Picker... your one Source for Everything in Radiography and Fluoroscopy

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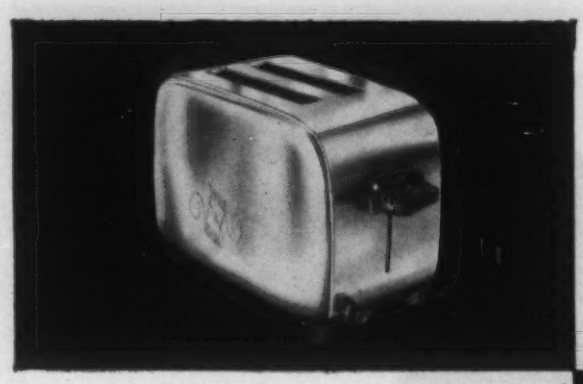
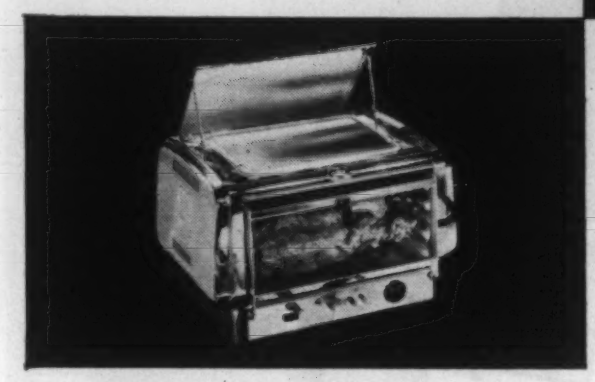


Capitol Products Co., Winsted, Conn. — Triple plated (copper-nickel-chrome) steel toaster shell eliminates costly and dangerous hand buffing. Result: increased production, fewer rejects.

Century Enterprises, Inc., New York City — Fryer wrap-around of copper steel reduces scrap factor, eliminates post-plating. Result: increased production, lower cost, fewer rejects.



Marlun Manufacturing Co., Woodside, Long Island — Chrome steel rotisserie shell eliminates post-plating operation — saves 20% in production costs.

HOW MANY REJECTS CAN YOU AFFORD?

If you're plagued by a high scrap factor due to post-plating, buffing and excessive handling of plated metal components, check the advantages of pre-plated Nickeloid Metals. These modern *finished* raw materials have brought new methods of production to the appliance industry in a wide range of cost-saving applications: toaster shells, rotisserie bodies, fryer wrap-arounds, hot plates, heating element covers and decorative trim.

Nickeloid Metals help reduce rejects because they *eliminate three production steps*—plating, cleaning, buffing; *minimize handling operations*—the plated part moves from fabrication right into assembly; and the metal, itself, is *durably, uniformly pre-plated.*

Remember, too, that in most cases Nickeloid Metals fit right into standard production techniques—require no extensive re-tooling or special handling. For severe forming operations use Nickeloid Metals protected with Mar-Not, a protective coating that peels off.

CHROME, NICKEL, COPPER OR BRASS FINISHES ON BASE METALS OF STEEL, ZINC, COPPER, BRASS AND ALUMINUM. SHEETS, COILS AND STRIPS.

More Than a Metal — It's a Method!

NICKELOID METALS
SINCE 1898

Send for Free Sampler-Selector

Handy slide-chart gives specifications, finishes and typical uses for Nickeloid Metals Contains 8 metal samples.

AMERICAN NICKELOID COMPANY
Peru 6, Illinois

For more information, turn to Reader Service Card, Circle No. 378

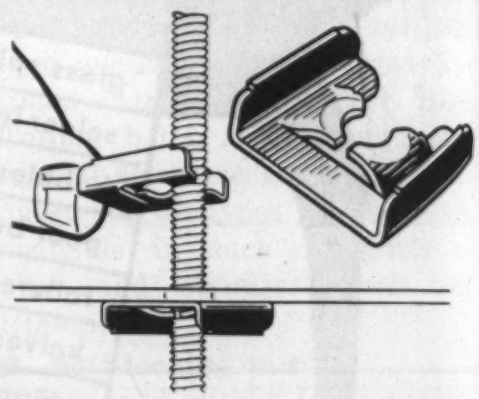
OTHER NEW MATERIALS PRODUCTS

mounted unit, the nut can be turned down compressing the spring and making a solid mounting which cannot shift. Upon delivery the self-locking nut is backed off to the proper spring tension to float the unit.

The base flange against which the spring seats is 1 in. in dia. A red fiber insert provides the locking.

3. Aircraft speed nut

A nut with an open side has been developed by *Tinnerman Products, Inc.*, Cleveland, Ohio, to replace square nuts that must be



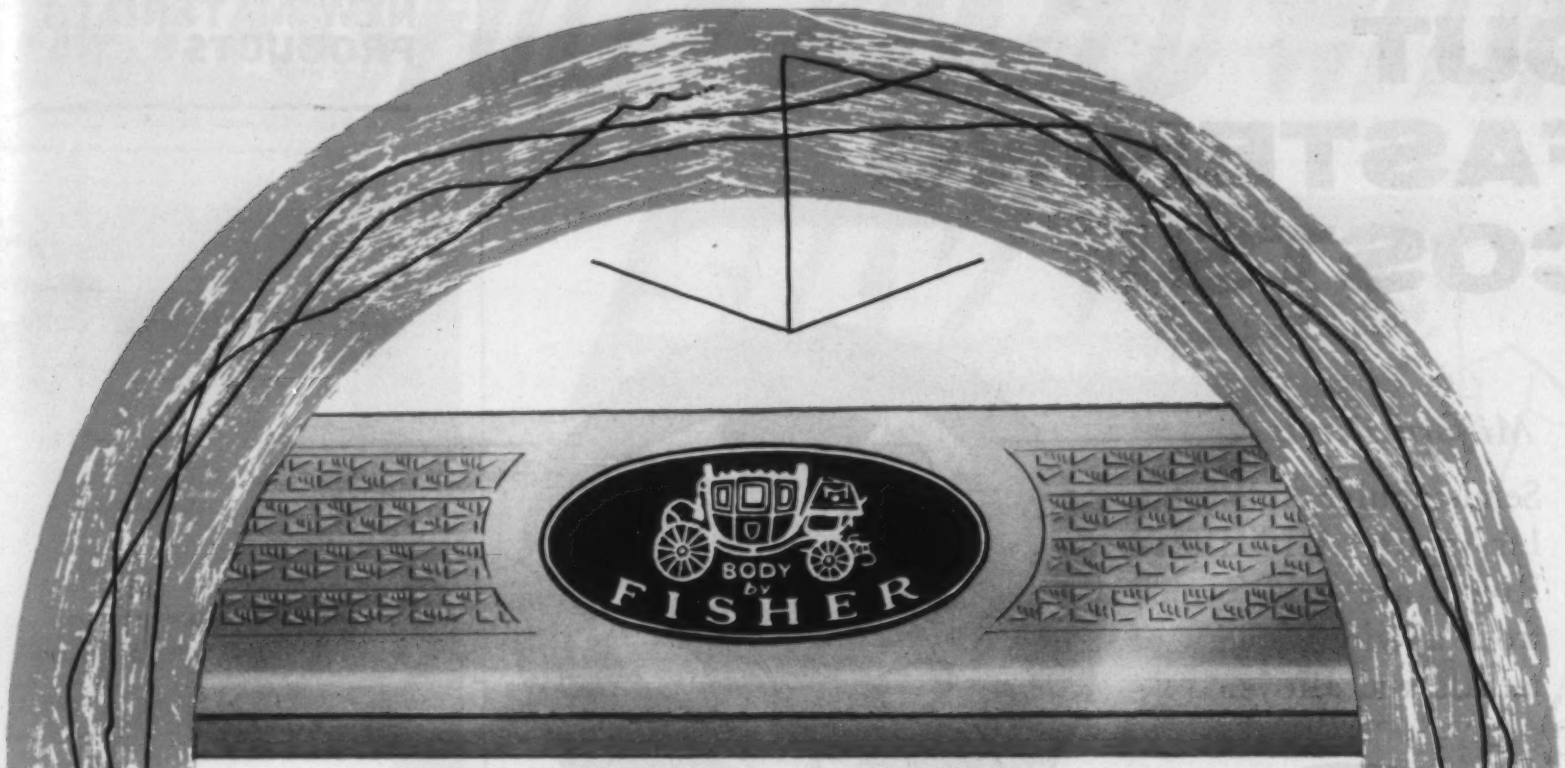
How it works *One side opening permits fastener to be placed onto template rod at any point and tightened with one or two turns.*

threaded up long rods on aluminum templates used in making plaster molds and mock-ups. After the threaded template rods are inserted into the template, the nuts, called Speed Nuts, are slipped onto the rods and tightened to hold the plates securely in place.

4. Ball and socket

A "ball and socket" type design on a new Knob Shoe Assembly manufactured by *Standard Parts Co.*, 1000 Broadway, Bedford, Ohio, gives up to 12 deg movement in any direction in contrast to an older pin fastening method which limited angular movement to only two directions.

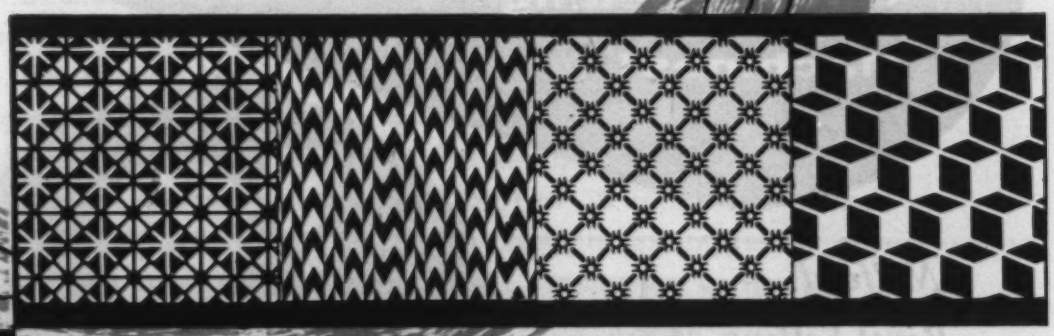
The fastener makes assembly possible in close quarters. When the round head of the screw is in-



Automobile door sill which previously was etched
is now produced at lower cost by ROLBOS "stop-roll" embossing.
Emblem is actually reproduced in two colors on the sill plate itself.

Rolbos turns ideas into reality

"STOP-ROLL" EMBOSSING



Design effects previously only secured by etching may now be produced more economically on production runs by ROLBOS "stop-roll" embossing. Thousands of designs are available; practically any may be created to your specification. "Stop-roll" is unique in that the design may be stopped at any desired place for identification insertion and then the design is continued or a new pattern started. Array of brilliant color anodized aluminum is available.

To help you transform your design ideas into practical production items, we can create and then produce for you exciting style in Trim and Parts thru our many processes and engineering-design services. Your inquiry is invited.

Write to:

ELECTRO-CHEMICAL ENGRAVING CO., INC.
1102 Brook Avenue, New York 56, N. Y.

ETCHED PRODUCTS CORPORATION
39-01 Queens Boulevard, Long Island City 4, N. Y.

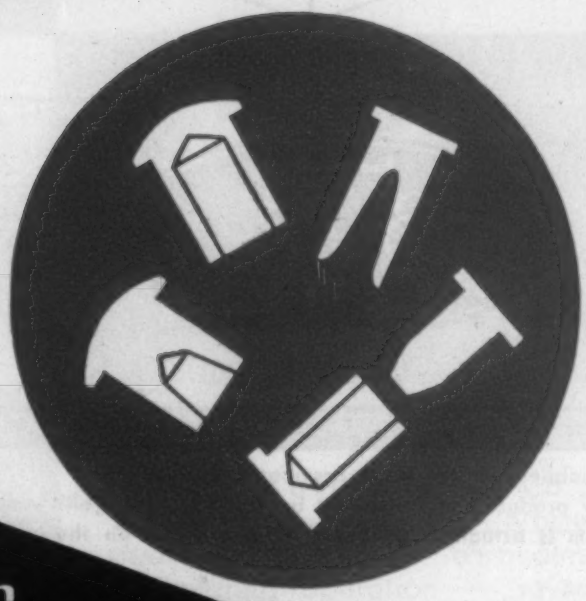
Rolbos — roller embossing (including "stop-roll"). **Embos** — mechanical embossing.
Etchrite — sharp etching. **Kolfor** — cold forged coined letters with integral lug.
Lithographing * Stamping * Anodizing * Plating * Enameling Working in All Metals.

For more information, turn to Reader Service Card, Circle No. 532

CUT FASTENING COSTS!

Milford Rivets

Semi-tubular, full-tubular, split. All Milford Rivets are cold-formed from a wide variety of metals and alloys.



Here's A Team That Does It For You— Milford Tubular Rivets & Rivet-Setting Machines!

Milford Rivet-Setting Machines

A complete line of precision, high-speed Milford Rivet-Setting Machines for automatic assembly of your products.

Whatever your needs . . . tubular rivets; rivet-setting machines, special cold-formed fasteners or parts . . . Milford's five *manufacturing* plants give you unmatched service. To pare your fastening costs, to increase production—get in touch with Milford!

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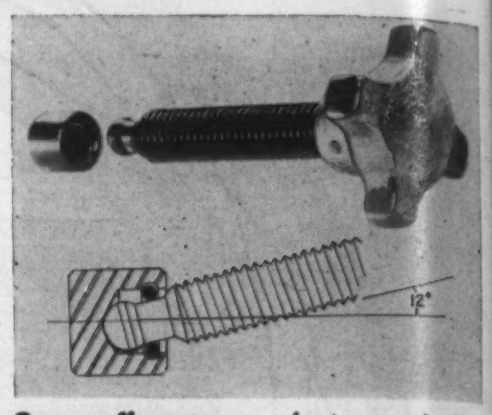
OTHER NEW MATERIALS PRODUCTS



Snap-off-snap-on *feature of this fastener makes assembly possible in difficult places.*

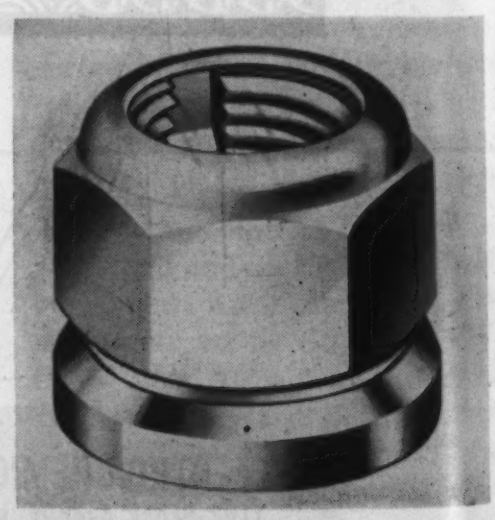
serted in the snap-ring, the shoe is held firmly in place after the screw returns to its original position.

The knob is cast iron and cadmium plated. The screw and shoe are case hardened and treated for protection from corrosion. The fastener is available in 12 standard sizes.

5. Washer-faced locknut

A new washer-faced locknut, called Dura-Loc CC-30 Washer-Nut, features a split threaded core within a hexagonal shell. Manufactured by *Delron Co., Inc.*, 5224 Southern Ave., South Gate, Calif., the assembly also contains a washer which provides adequate strength where full nut bearing area is not available, such as keyhole type mounting flanges and similar applications.

The assembly works as follows: when axial movement of the shell



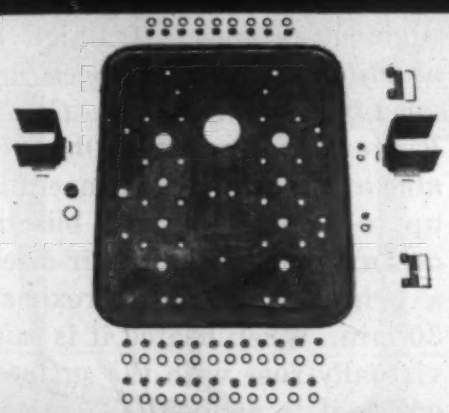
Steel washer-nut *useful for keyhole type flange mountings for generators, starters or any application where a washer-faced locknut is required.*

SUCCESSFULLY BRAZED WITH

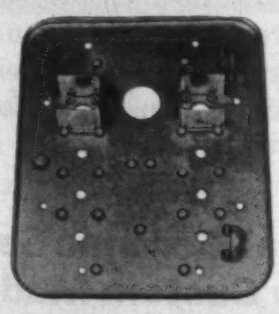
SILVALOY

LOW TEMPERATURE SILVER BRAZING ALLOY

All joints in these assemblies are being silver brazed successfully with Silvaloy 50 preforms and APW 1100 Flux.



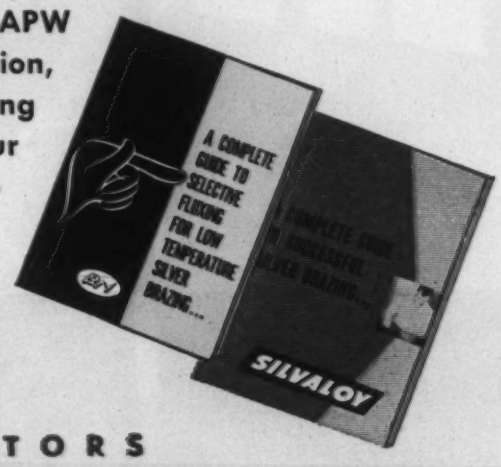
Electro-Voice
INCORPORATED ®



Here's an unusual brazing job, cleverly engineered at Electro-Voice, Inc., one of the nation's leading manufacturers of Electro acoustical products and communication equipment, in Buchanan, Michigan. This unit is a shipboard microphone station manufactured to critical Naval specifications.

The section being inserted into the furnace is a brass box assembly having 40 joints brazed simultaneously. The lower photographs show the cover assembly to be handled in the same manner, in which a total of 39 joints are brazed in a single operation. Both are excellent examples of outstanding engineering and efficient production control.

Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy Distributor for information or technical assistance.



These two complete reference manuals for low temperature silver brazing and fluxing are available upon request. Send for either one or both.

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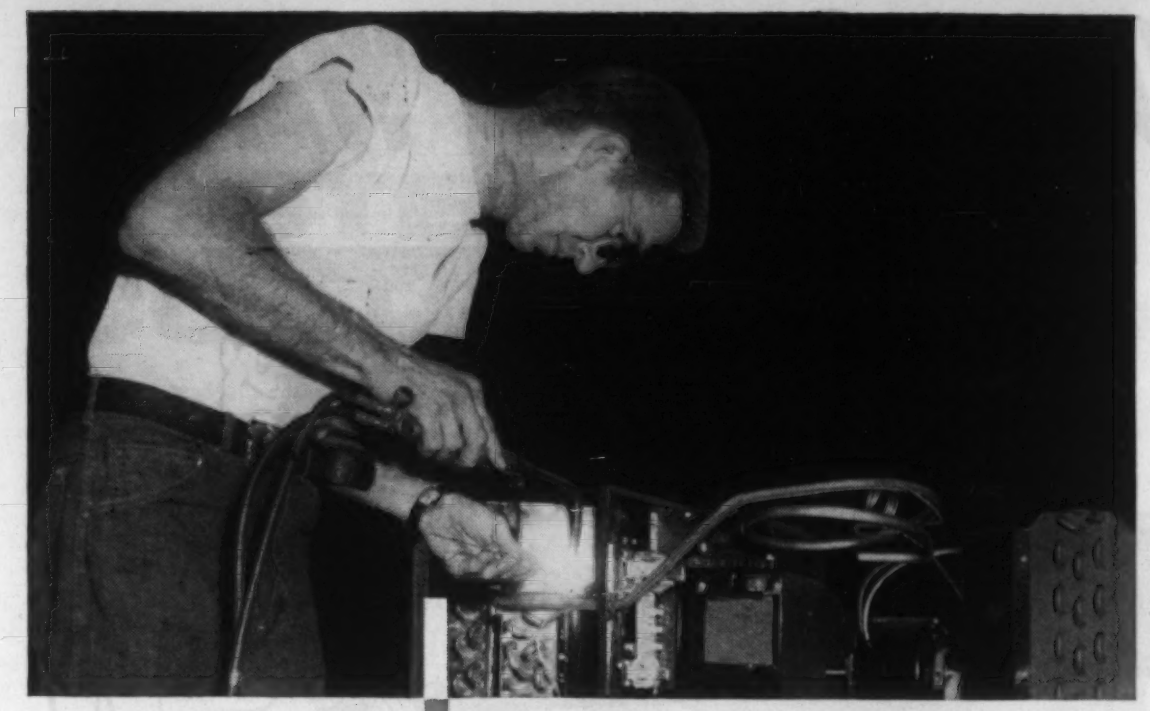

important announcement to *United* brazing customers

If you are presently using United Phoson 15 alloy (government grade III) this is notification that a switch to Phoson 6, the most talked about brazing alloy in the country, will cut your costs at least 30 per cent with *equal performance* in every respect.

Extensive field tests—eight years of them—have proven Phoson 6 best for brazing copper and brass. Most of United's customers, 80 per cent, in fact, have already changed.

here's the story!

Silver 6%.....Brazing Temperature 1300°
Copper 87¾%....Original Tensile 92,000 PSI
Phosphorous 6¼%.....Rockwell 15T 86
AWS BCuP 3

Write for the facts today.

Permanently United
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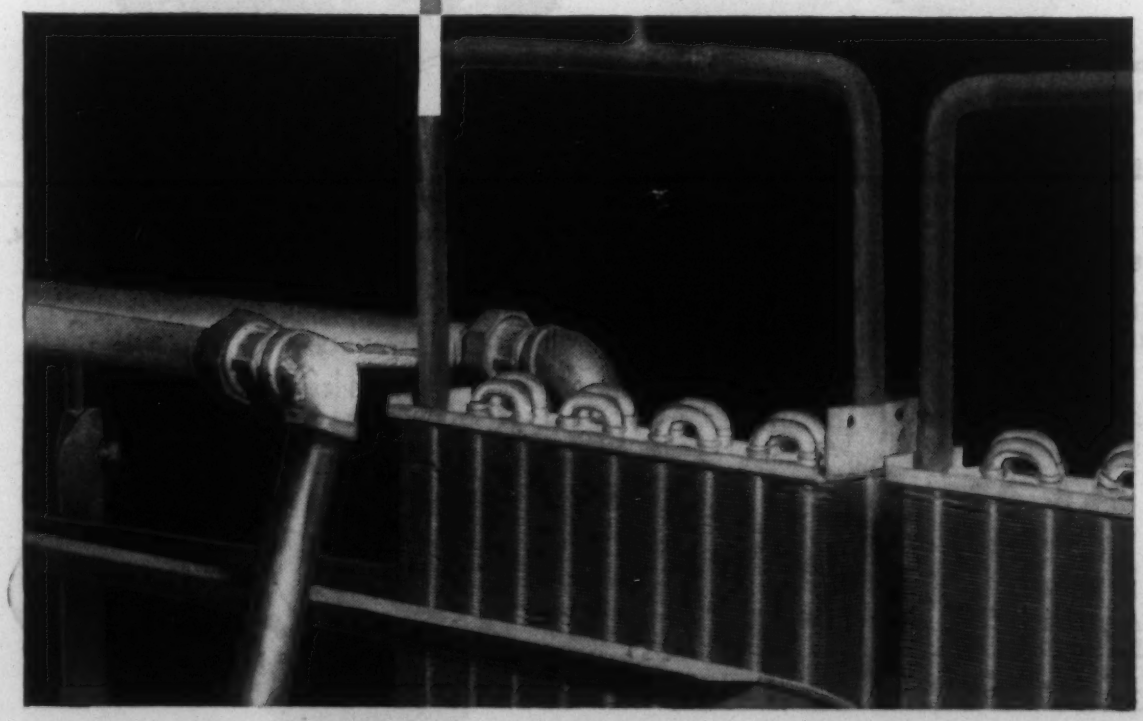


For more information, turn to Reader Service Card, Circle No. 507

is stopped, further rotation of the nut forces the tapered core down and around the bolt, securely locking the nut in place. Enough movement of the core is provided to insure equal locking on high or low tolerance bolts.

The washer-nut is made of C1137 steel, and is cadmium plated in sizes ¼-28 to 7/16-20.

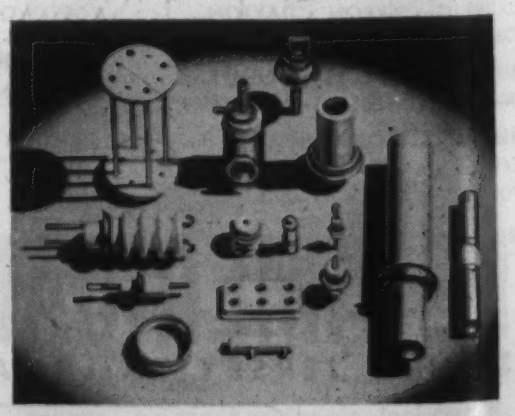
Silicone-Aluminum Paint Is Nonblistering

Composed of a clear silicone base with a special aluminum flake pigment, a new extra-high heat aluminum paint has been developed by *Chem Industrial Co.*, 3784 Ridge Rd., Brooklyn, Ohio. Capable of withstanding temperatures up to 1700° F without blistering or burning, the paint air-dries to a bright finish in approximately 30 min. When heated it is said to virtually fuse with the surface on which it is applied.

The paint, which can be applied by either brush or spray gun, resists moisture, corrosion, mild acids, alkalis and industrial fumes. It is recommended for use on condensers, heat lines, ovens, radiators and exhaust manifolds.

Metal-Ceramic Seals Now Custom Made

Custom made metal-ceramic seals have been introduced by *American Lava Corp.*, Cherokee Blvd. & Mfgrs. Rd., Chattanooga 5, Tenn. Seals can be supplied for



***Typical seals** made for high temperature applications.*

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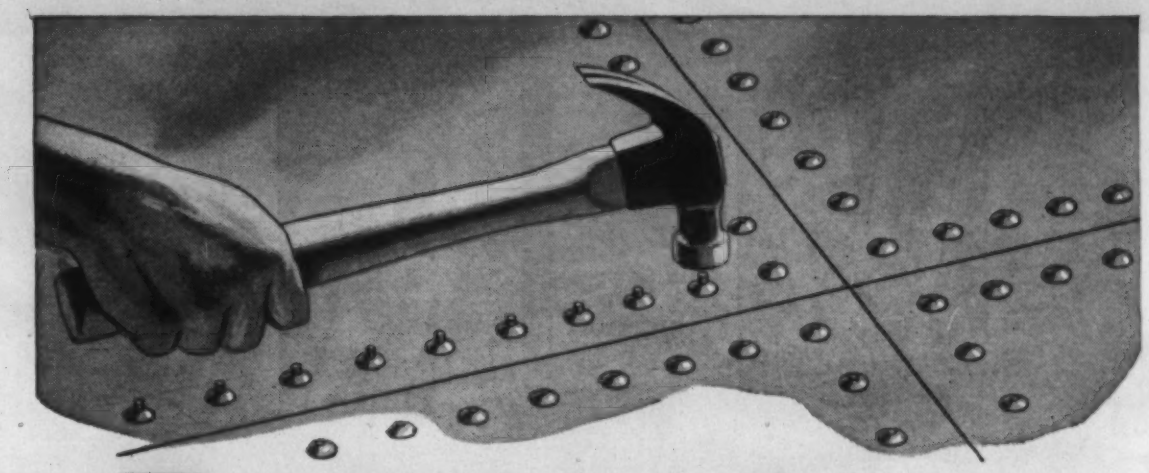
If your products call for aluminum tube, it will pay you to put your requirements up to Revere. For at this one source you can obtain virtually any aluminum tube you want . . . seamless drawn, welded, lockseam and others; in an extensive range of sizes, alloys and tempers; both round and other-than-round.

Revere has the men, machines and experience to produce tube that is right for its purpose as well as right on schedule. It will pay you to tie the progress of your business to the most dependable sources of supply. Call the nearest Revere Sales Office now. In all principal cities. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include extruded shapes, rod and bar; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn and welded tube; rolled shapes; electrical conductors; forgings; and foil. Revere is headquarters for tube, and can supply it not only in aluminum but in copper, copper-base alloys and electric welded steel.



The rivet you drive with a hammer!

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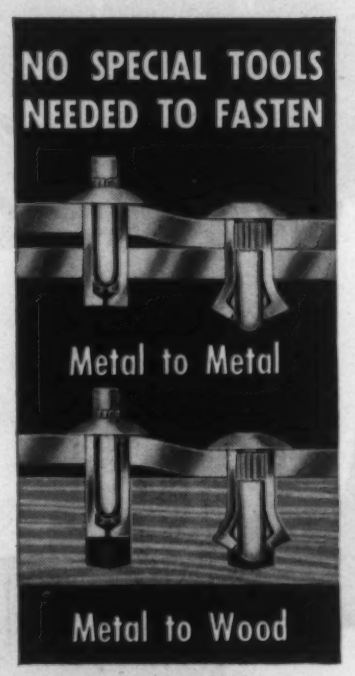
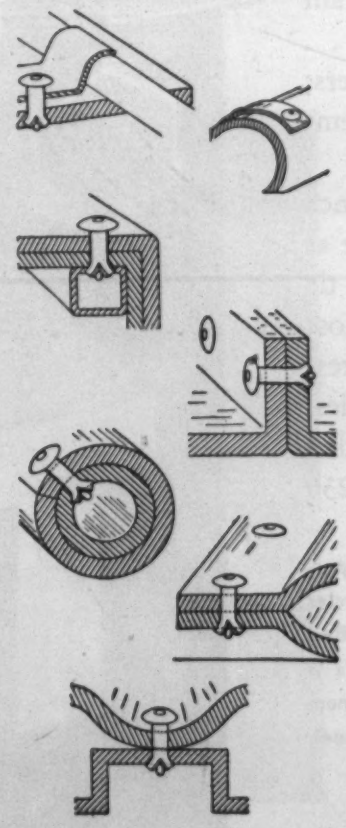
SPEEDS UP BLIND FASTENING! The Pin•Grip fastening method requires no special tools or skills and eliminates the use of costly, time consuming nuts, bolts or solid rivets.

Simply insert Pin•Grip into pre-drilled hole and drive the knurled pin flush with the rivet head with an ordinary hammer. Pin•Grip "pulls together" and locks materials into a permanent bond. Absorbs tensions, shocks, jars and vibrations.

Use Pin•Grip for every fastening application — metal to metal, metal to wood and compressible materials between panels. Just a few of the hundreds of uses for Pin•Grip are illustrated on the right. Available in a wide range of sizes in Universal, Countersunk and Full Brazier heads.



TYPICAL INSTALLATIONS



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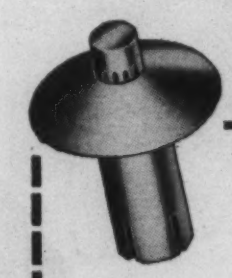

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silver solder brazing with hard or soft solder. Hard silver solder joints on high temperature designs have a minimum melting point of 1400 F.

Possessing good dielectric, high temperature and insulation properties, the seals are made of AlSiMag aluminas and a variety of metals. Metalizing and sealing techniques are said to give a permanent bond between the ceramic and metal. The seals have high tensile and impact strengths and are resistant to spalling and chipping.

Crepe Masking Tape Good for Hot Parts

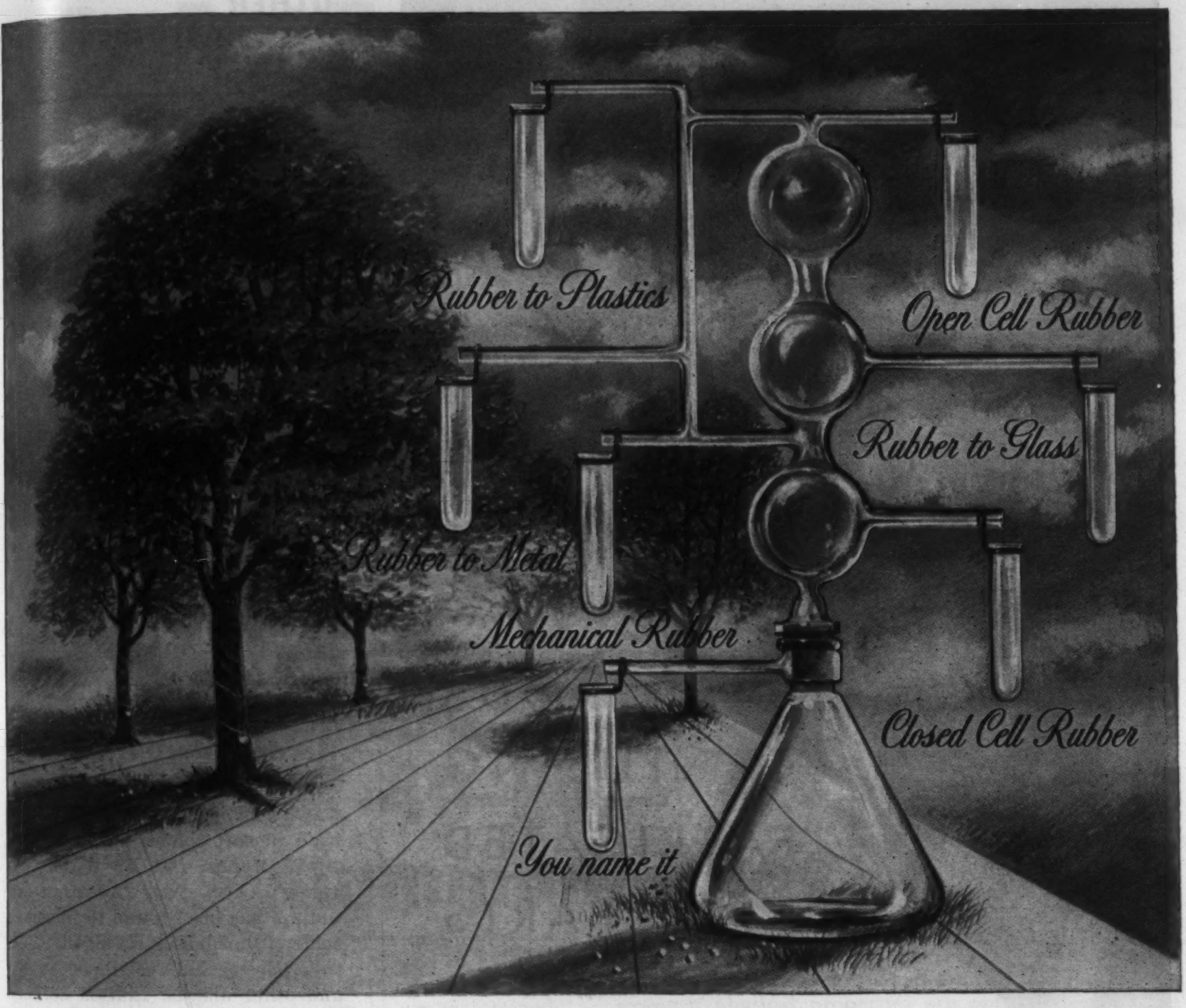
A new high temperature crepe masking tape, available in a full range of widths from ¼ in. up, has been announced by *Behr-Manning Co.*, Troy, N. Y. Tensile strength of the tape, called No. 102 Behr-cat, is 20 lb per in. of width, and elongation is 13.5%. A 9-mil tape has an adhesion to stainless steel of 33 oz per in. of width.

Recommended for general purpose use in a variety of masking operations, the pressure sensitive tape will resist temperatures of at least 275 F for 1 hr.

Stable Metallizing Dye

Permanent color stability features a dip dye developed for metallizing processes by *Schwartz Chemical Co., Inc.*, 326 W. 70th St., New York 23, N. Y. The formulation, called Metallizing Dye, is a clear dye solution claimed to have no sediment or precipitated dyestuff. The color is reported to be extremely stable. There is no water spotting as a result of the final washing operation. In addition, the color does not bake out when used on metals at high temperatures. The dye is available in brass, gold and copper colors.

(more New Materials on p 202)



New Kind of Rubber Tree

Need rubber with special properties? In a special form? Name it. Chances are Rogers can make it!

Need a flotation device that is non-absorbent, chemically-resistant and practically indestructible? Want to dampen vibration, or mount assemblies so they will float through shocks? Got an ozone or insulating problem to lick?

These are some of the jobs that our specialty rubber products are doing for others and can do for you. Our range of products includes cellular and mechanical types — hard as ebonite, soft as a sponge — using natural or synthetic latices.

We are not only equipped to develop special rubber compounds, but also to convert them into finished parts — by sheeting, blanking, forming, molding or laminating. *For more details about our specialty rubber products and services, please write Dept. M for our booklet "Engineered Rubber Specialties."*

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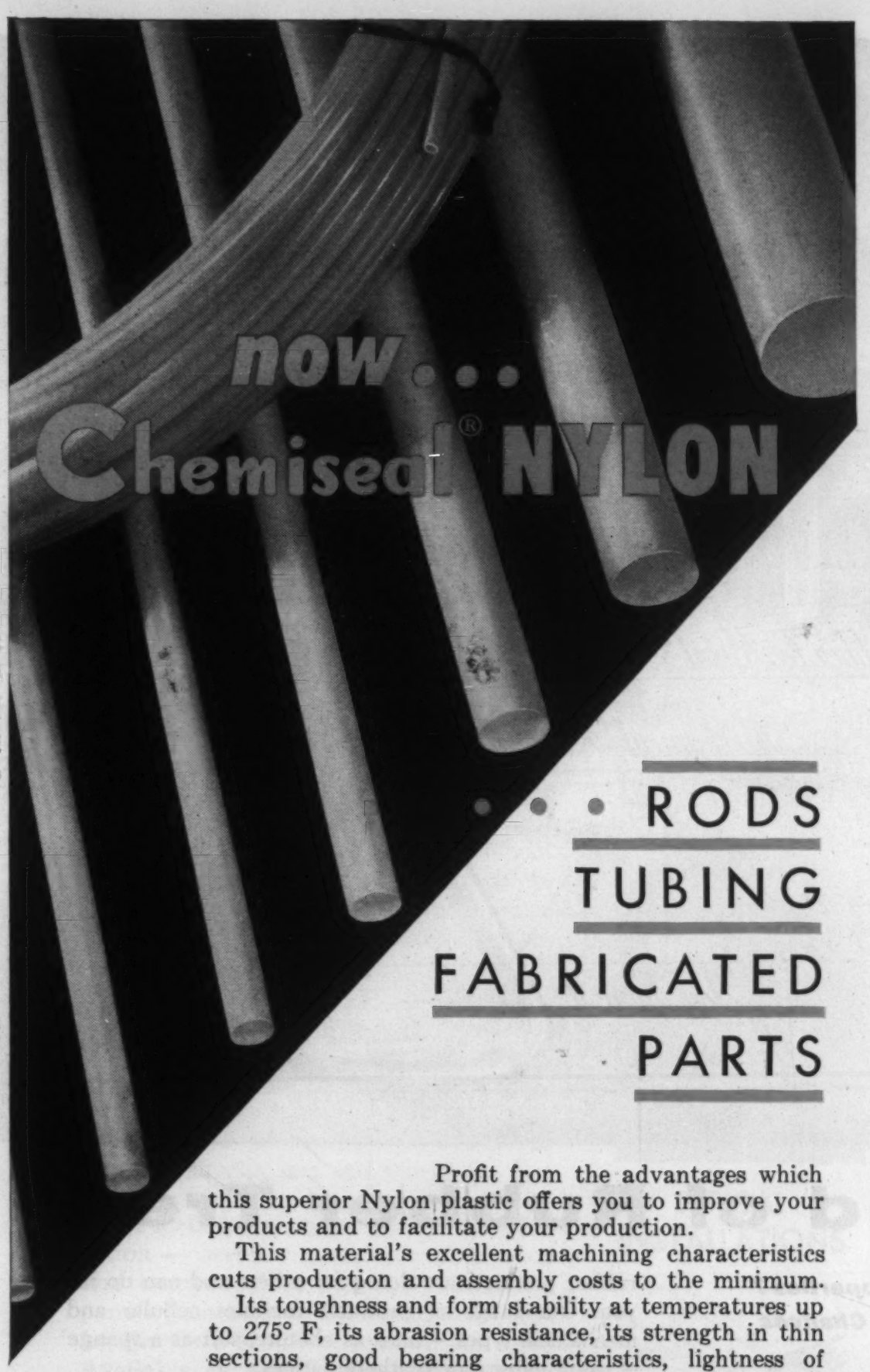

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PARTS

Profit from the advantages which this superior Nylon plastic offers you to improve your products and to facilitate your production.

This material's excellent machining characteristics cuts production and assembly costs to the minimum.

Its toughness and form stability at temperatures up to 275° F, its abrasion resistance, its strength in thin sections, good bearing characteristics, lightness of weight, chemical resistance and good electrical insulating properties recommend it for a wide variety of mechanical and electro-mechanical applications.

Specify Chemiseal Nylon Rod and Chemiseal Nylon Tubing (du Pont ZYTEL) now fabricated by United States Gasket Company "Quality Control" methods.

Available in all standard rod sizes from ⅛" to 2" inc. Tubing is supplied in sizes up to ½" dia. OD in various wall thicknesses. Precision machined parts to your specifications.

Write for further information.

U S G BELMONT

UNITED STATES GASKET CO.

CAMDEN 1, NEW JERSEY

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OTHER NEW MATERIALS PRODUCTS

Self-Vulcanizing Liquid Rubber Paint

A new liquid rubber paint that is said to be acid and alkali resistant, as well as moisture resistant, has been announced by *Adhesive Products Corp.*, 1660 Boone Ave., New York 60, N. Y. The self-vulcanizing paint requires no mixing and can be applied by brush or spray to metal, wood, plastics and concrete. It dries within 20 to 30 min and when properly applied is said to withstand 5 to 10 yrs of use. The paint is said to resist fungus, oil, gasoline, naptha and other solvents.

Solders with Indium Harder, More Resistant

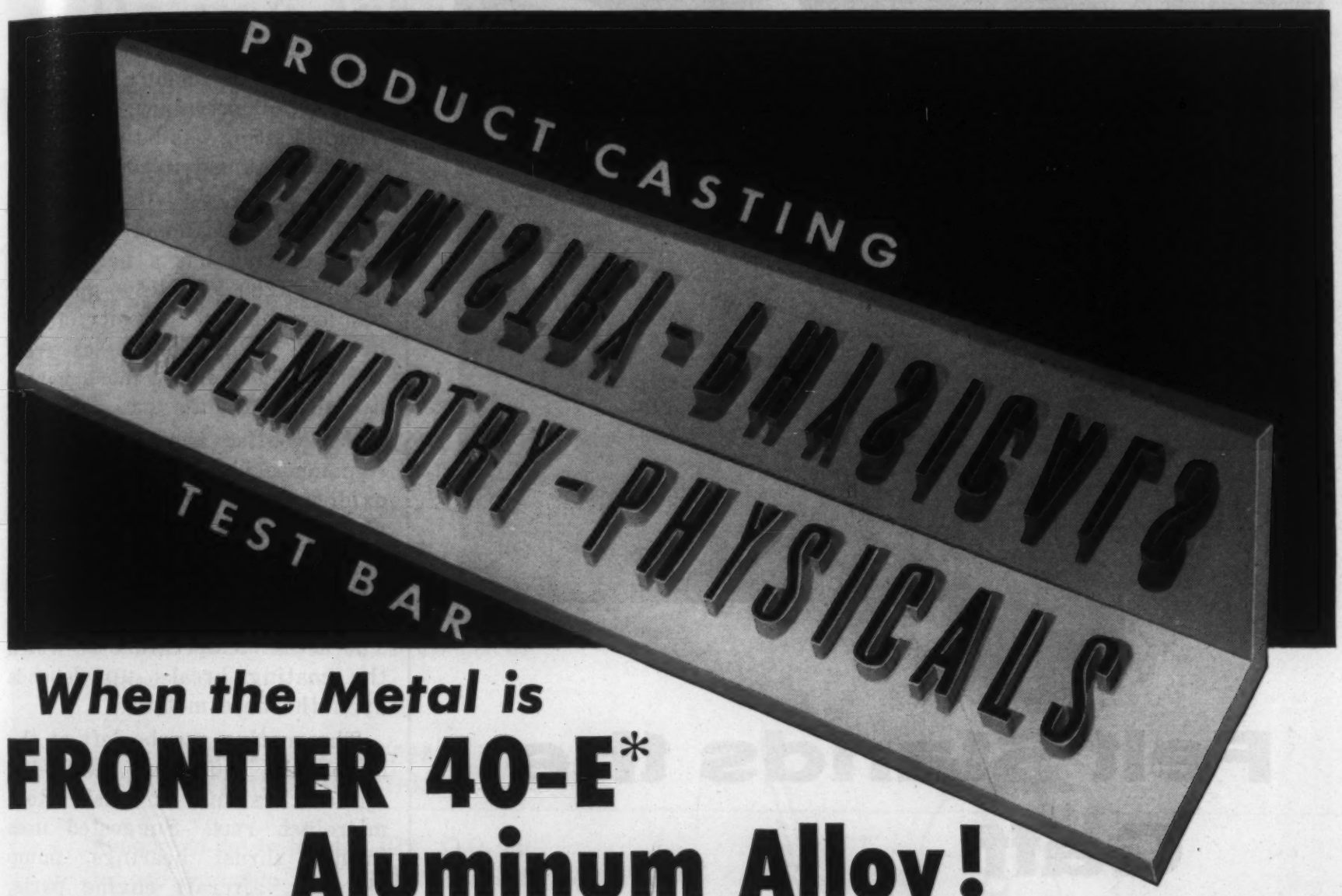
Indium, in combination with tin, lead and silver, is now being used in soft solders developed by *Alpha Metals, Inc.*, 56 Water St., Jersey City, N.J. Addition of indium has been found to increase solders' hardness, strength, wetting power, and resistance to lye and other alkalis. Indium solders are applied in the same way as the conventional sweating type solders and no special equipment is needed for their use. They have found use in electrical junctions, transistor electrodes and mirror mountings.

Higher indium contents have been found to produce better bonds, whereas lower amounts give good electrical and physical properties and harder and higher melting solders. Twelve different alloys bearing indium are available, melting temperatures ranging from 243 to 599 F.

Alumina Coatings Now 'Flame Plated'

Linde Air Products Co., 30 E. 42nd St., New York 17, N.Y., has introduced aluminum oxide for 'Flame Plating' of parts subject to continuous wear. The new coat-

The Test Bar Mirrors the Quality of the Product Casting



When the Metal is FRONTIER 40-E* Aluminum Alloy!

Whether you purchase Frontier 40-E Aluminum Alloy castings direct or from a foundry licensed to produce this alloy, you can be sure that the high qualities that have made this alloy famous are being maintained. How is this controlled? Test bars are required from all licensees. These are sent to the technical research laboratory of the Frontier Bronze Corp. for complete analysis and physical testing.

One of the most unusual features of Frontier 40-E Aluminum Alloy is the fact that the physical properties which spell high quality in the test bar appear uniformly throughout a large casting. And since Frontier 40-E is a non-heat-treated aluminum alloy the high strength physical properties are obtained by natural aging at room temperatures. The high yield strength of Frontier 40-E Aluminum Alloy is of special value in designing parts that must be light in weight and yet resist distortion or deformation.

Yes, the test bar mirrors the quality of the product casting . . . here's proof.

FRONTIER 40-E	TEST BAR	CASTING
Yield Strength	23,500	22,700
Tensile Strength	36,600	35,500
Elongation	7.5	7.5

*REG. T. M.

Please send me a copy of the Alloy Data Book giving Engineering and Metallurgical Facts on the physical properties of Frontier "40-E".

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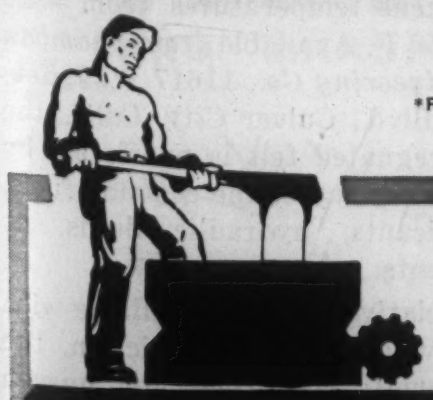

FRONTIER BRONZE CORPORATION

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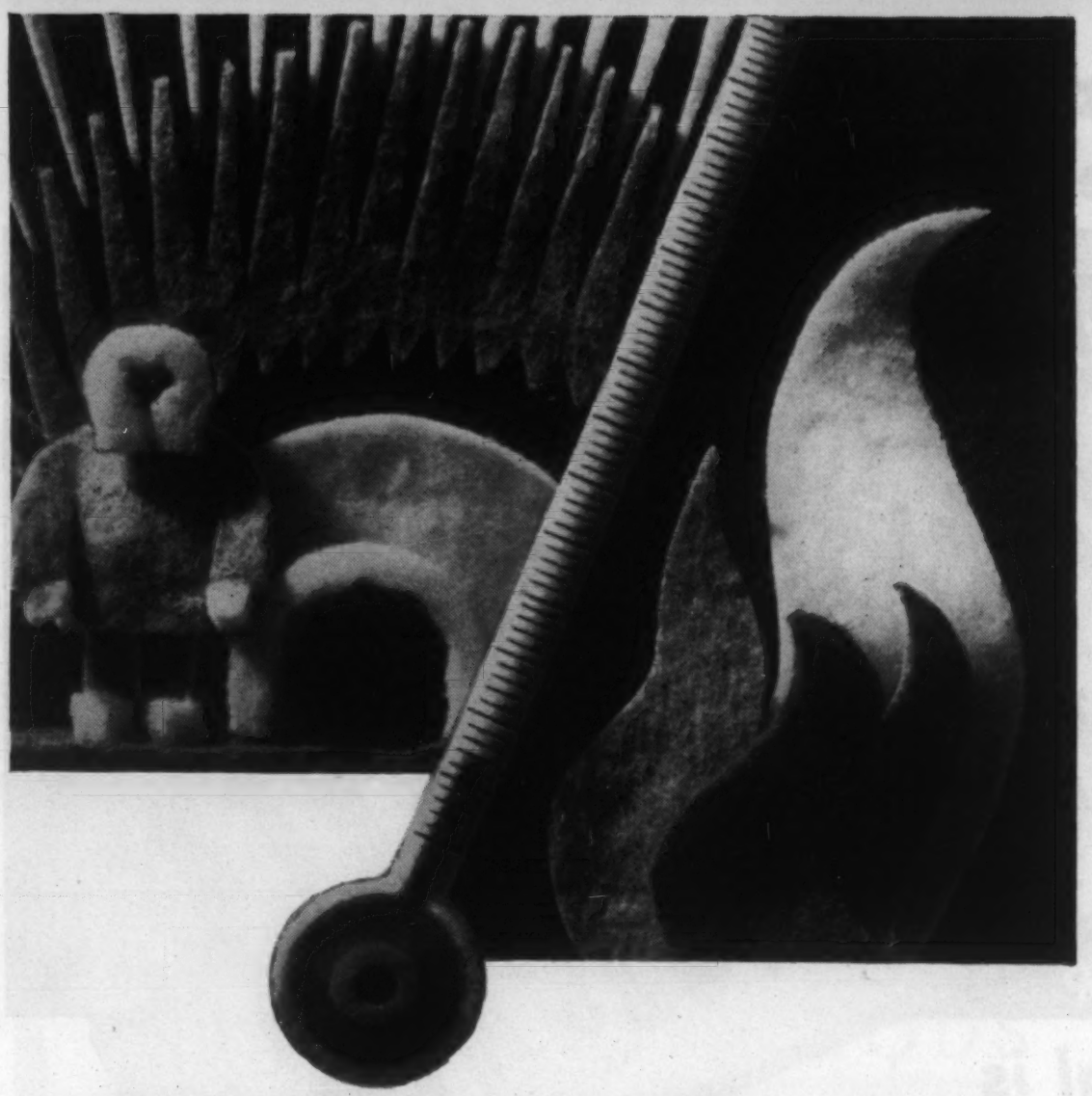
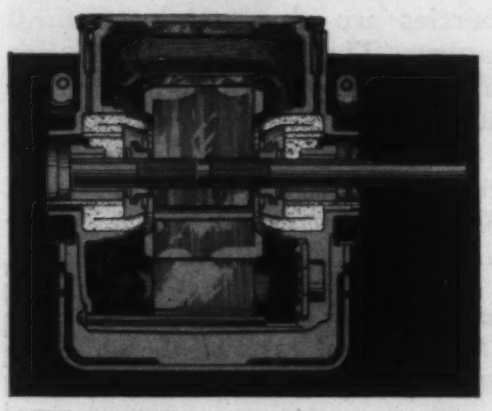


Felt Stands the Gaff

...FROM −80°F TO 250°F



FELT IN USE . . . Small motors use felt washers, rectangles, odd shapes and wicks in many places to increase reliability, like on this Redmond Micromotor shown here. Felt wicking and pourous bronze bushings provide positive lubrication for long, heavy-duty operation in any position. Felt seals also keep dirt and dust out of vital areas.

Felt by Felters has what it takes when operating conditions are extreme.

Stands over 30 days at 250°F of dry heat without materially weakening its structure. Same at −60°F as at normal 74°F and at −80°F its properties are only slightly different. Even when exposed to greater extremes, felt will always resume its natural feel.

Send for Design Book

Complete technical data has been prepared for your use in selecting and specifying the *right* felt for the job your product has to do. Send for it today. The Felters Company, 220 South St., Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — *Representatives in All Principal Cities*

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OTHER NEW MATERIALS PRODUCTS

ing is useful where resistance to erosion and corrosion at high temperatures is necessary. Previously Flame Plating has been used only to apply tungsten carbide coatings.

The 99% gamma aluminum oxide coating has a hardness of 1000 to 1200 VPN (300-gm load) and less than 1% porosity. It can be applied in thicknesses from 0.001 to 0.040 in. on most metals, ceramics and glass.

The coating is not affected by common acid and salt solutions, oxidizing and reducing atmospheres, and many low temperature molten metals. It does not begin to deteriorate below 1200 F and in some cases not below 1800 F. The actual temperature at which the coating breaks up depends upon the base metal.

The coating can be left at the as-coated roughness (125-150 microinches rms) or finished to 1 microinch rms. Suggested uses include thrust bearings, pump plungers, aircraft engine parts, guided missile components, electronic components exposed to heat, and seals operating under heat and in corrosive media.

Teflon Felt for Use as Seals or Gaskets

A Teflon resin-impregnated Teflon felt—more resilient than Teflon plastics—has been developed for resilient gaskets for use in severe physical and chemical environments.

Designated Compound S-16810, the material is said to withstand ambient temperatures from −320 to 550 F. Available from *Shamban Engineering Co.*, 11617 W. Jefferson Blvd., Culver City, Calif., the impregnated felt is unaffected by water or any of the common fuels, lubricants, hydraulic fluids, or solvents.

Relatively soft and pliable with a low coefficient of friction, the material conforms to uneven

Do you fabricate parts from Brass or Copper Straight Lengths or Copper Coils?

To be sure of the tubing you want *when* you want it, *now* is the time to place your order — before the air conditioning rush begins. Getting your specifications now, will permit us to examine your needs carefully and to make ready all of the production facilities your order will require. So to avoid delays, to help us keep you supplied with the tubing you will need when your own production is stepped up, we urge you to contact us without delay.

BRASS AND COPPER STRAIGHT LENGTHS

Random or cut to length; .072" O.D. up to and including 1¾" O.D. with wall thickness of .065" and lighter.

COILED COPPER TUBING

Standard 50' refrigeration coils are available from ⅛" O.D. to and including ⅝" O.D. in wall thicknesses from .030" to and including .035". Extra soft deoxidized, bright annealed. Ends are capped, plugged or crimped as you require.

ORDER NOW FOR SPRING AIR CONDITIONING SALES!

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Expect the BEST brass and copper products from

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METALFLO LOCKSEAM COIL STRIP AND SEAMLESS TUBING TUBULAR PARTS

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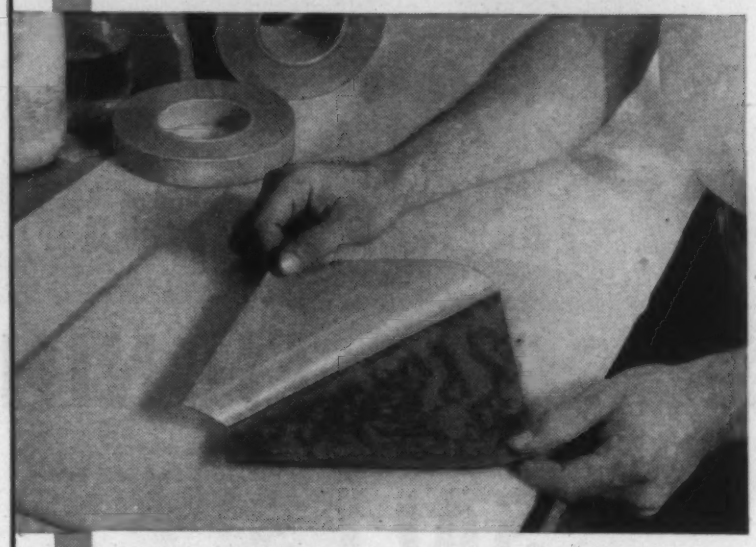
the first of its kind

a more versatile medium for

pressure sensitive instant adhesion



ANGIER'S **Double-Face*** **PRESSURE SENSITIVE Transfer Film**

Entirely different from conventional double-coated tapes. "Double-Face" is a specially reinforced pressure sensitive mass incorporating the features of conformance, adhesion and aggressive tack provided by many liquid pressure sensitive applications. It is a **translucent** pressure sensitive mass in film form supported by a double-coated release paper which can be either removed at once for instant bonding or at a later date if used on a consumer product.

* TRADE MARK OF INTERCHEMICAL CORPORATION

- **adaptable to a full variety of porous and non-porous materials.**
- **conforms to highly irregular surfaces.**
- **can be slit or die cut with protective release paper in place.**
- **eliminates drying and coating equipment.**
- **speeds production — reduces waste.**

Available in rolls: Widths: 1/8" up to 54"
Length: 72 linear yards

3 Types: SOFT MEDIUM FIRM

Write for samples, specifications and prices.

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Division of Interchemical Corporation
120 Potter Street Cambridge 42, Mass.
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Latest developments in Adhesives for
Honeycomb Construction, Vinyl Film Bonding
Rubber, Latex and Resin Cements
Pressure Sensitive Cements Flocking Cements
Laminants and Sealants Tie Coats Resin Emulsions

ANGIER ADHESIVES

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OTHER NEW MATERIALS PRODUCTS

flanges and provides durable static or moving low pressure seals. It is particularly adaptable for use with glass and glass-lined equipment, because glass will conform to uneven flanges at low pressures. The hazard of damage to the equipment or extrusion of the gasket material from unnecessarily high pressures is minimized.

Applications include gaskets or seals in aircraft and missiles, and gasketing in chemical plants, where both extreme temperatures and corrosive chemicals are involved. The impregnated felt is available in thicknesses of 1/16, 1/8 and 1/4 in.

Polyester Varnish for Class B Insulation

A Class B insulating varnish has been developed by *Schenectady Varnish Co., Inc.*, Schnectady, N.Y., for use with the new Class B wire enamels. The polyester type varnish is said to have handling and curing characteristics adapted to manufacturing cycles and curing temperatures currently used by electrical manufacturers.

Designated Isonel varnish, the material is claimed to have two to eight times the life of conventional Class A varnishes when aged at 392 F and subjected periodically to a 2000-v dielectric test. Varnishes applied over wire enamels have shown no failures after 2500 hrs at 392 F.

Power factor of the varnish is claimed to be equivalent to that of Class A varnishes at temperatures from 68 to 266 F. It cures at 375-400 F, the length of baking cycle depending on the size of the impregnated coil. It is claimed that in many cases a 1-hr cure is adequate.

The varnish is noncorrosive and is handled in the same manner as regular varnishes. Recommended thinner for the material is mineral spirits.

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CONTENTS NOTED

Highlights of current papers plus a list of recent books and reports.

This month

- *Influence of lead on fatigue properties*
- *New test for potting resins*
- *Calculating gray iron properties*
- *Improving adherence of porcelain enamels*

Fatigue Properties of Leaded Steels

Leaded steels are finding increasing use in heavy duty parts and other components. Such parts are often subjected to fluctuating loads in the presence of stress raisers.

In order to assess the behavior of leaded steels with and without stress raisers, W. E. Bardgett conducted tests on both plain and notched, leaded and nonleaded steel specimens. Results are described in the Aug '56 issue of *Iron & Steel.*

One heat of steel (A) was tested at three different tensile levels—125,000, 157,000 and 245,000 psi. Two additional heats were chosen from a second composition. One of them (B) was treated to the lowest tensile level of the first heat and the other (C) to the middle value in order to provide a comparison with the first heat. Chemical compositions of the steels are shown in Table 1.

Unnotched fatigue

All fatigue tests were carried out on Wohler rotating cantilever machines using single point loading. The fatigue test results, based on an endurance limit of 10 million stress reversals, are shown in Table 2.

The effect of the addition of lead to the 1½% Ni-Cr-Mo steel (A), in the absence of stress raisers, is to reduce the limiting fatigue stress and the fatigue ratio at all three levels of tensile strength. Reduction in fatigue ratio becomes more marked with increase in tensile strength, being negligible (less than 2%) at the 125,000 psi tensile level, increasing to 5% at the 157,000 psi tensile level, and increasing to 19% at the 245,000 psi tensile level.

Reduction in fatigue ratio of the two Ni-Cr steels (B and C) is somewhat greater than that of the 1½% Ni-Cr-Mo steel (A) for corresponding tensile strength, being 6% at the 125,000 tensile level and 12.5% at the 157,000 psi tensile level.

Notched fatigue

In the presence of a notch, the effect of lead is of no practical significance. At the highest tensile level of approximately 245,000

TABLE 1—COMPOSITION (%) OF NONLEADED AND LEADED STEELS

Steel	Type	C	Mn	Si	S	P	Ni	Cr	Mo	Pb[a]
A	1½% Ni-Cr-Mo	0.37	0.64	0.22	0.030	0.025	1.53	1.06	0.21	0.19
B	3% Ni-Cr	0.11	0.45	0.21	0.031	0.020	3.08	0.76	—	0.18
C	3% Ni-Cr	0.14	0.48	0.25	0.028	0.020	3.16	0.88	—	0.19

[a]Leaded quality only.

TABLE 2—FATIGUE PROPERTIES OF NONLEADED AND LEADED STEELS[a]

Steel	Type	Quality	Tensile Strength, psi	Plain Specimens		Notched Specimens	
				Limiting Fatigue Stress, ± psi	Fatigue Ratio (IFS/TS)	Limiting Fatigue Stress, ± psi	Fatigue Ratio (LFS/TS)
A	1½% Ni-Cr-Mo	Nonleaded	125,400	71,200	0.57	29,800	0.24
		Leaded	124,300	69,400	0.56	28,700	0.23
		Nonleaded	152,800	88,500	0.58	33,100	0.22
		Leaded	151,200	82,900	0.55	33,100	0.22
		Nonleaded	244,800	114,900	0.47	47,700	0.19
		Leaded	243,000	93,000	0.38	44,800	0.18
B	3% Ni-Cr	Nonleaded	123,200	62,700	0.51	30,200	0.25
		Leaded	121,000	58,200	0.48	31,400	0.26
C	3% Ni-Cr	Nonleaded	166,400	79,500	0.48	33,100	0.20
		Leaded	158,300	67,200	0.42	31,400	0.20

[a]Based on endurance limit of 10 million stress reversals.

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psi, the reduction in fatigue ratio due to lead in the Ni-Cr-Mo steel is only from 0.19 to 0.18. At the 125,000 psi tensile level in the Ni-Cr steel, the fatigue ratio is actually increased from 0.25 to 0.26.

The presence of lead, the author concludes, only gives rise to lower fatigue values at high levels of tensile strength and where no stress raiser is present. Such conditions rarely arise in engineering practice.

New Test for Potting Resins

Delicate electrical components potted in a casting resin are particularly susceptible to damage from resin cracking during thermal cycling. Inserts with thermal expansivity differing from that of the resin increase this possibility. Thus it is important to have a reliable thermal shock test that will 1) help in designing and in selecting materials for potted components, and 2) measure the effects of additional materials such as fillers or plasticizers used to reduce expansivity or lower brittleness temperatures of the resins. A new method for determining fracture temperature, as well as the precise rate of cooling for potted components, was described by L. S. Buchoff of Westinghouse in the August *SPE Journal*.

Test method

The new test is based on the standard hex bar test which is widely used by the military. The standard hex bar test consists of casting a mild steel hex bar in each resin to be evaluated, thermally cycling the specimens through specific temperature ranges, and then examining them for cracks. The resin showing the fewest cracks is considered the most resistant to thermal shock. This test at best evaluates resins only between two fixed temperatures.

The new test is designed to pinpoint the fracture temperature when a hex bar specimen is cooled at a specific rate. This is accomplished by wrapping the hex bar with AWG No. 40 (0.0031 in. dia) insulated wire before potting. The average temperature of the specimen during testing can be obtained by measuring the resistance of the wire, since resistivity of copper is directly proportional to temperature over the testing range. The temperature measurements produce a cooling curve, and when the resin cracks the wire is broken, causing an open circuit. Readings are taken every minute or half minute until the wire breaks. The last reading before the wire breaks is taken as the fracture temperature.

In testing some types of resins (such as epoxy catalyzed with diethylenetriamine) hairline cracks were observed in the material though the wire did not fracture. To test these types of specimens, paths of conductive silver paint are applied to the resin surface. Resistance of the paint is also directly proportional to temperature. In all tests conducted, the painted circuits were opened by the cracking of the resin.

By using both wire and paint the extent and size of cracking can be determined on some specimens. Correlation between paint and wire techniques is good, since temperatures indicated on the outside of specimens fall within the range of experimental error of the internal temperature.

Other uses of technique

The thicker the casting the more important the temperature gradient across it and the rate of temperature change. By using both wire and painted circuit techniques, temperature gradient and cooling curves can be found simultaneously. The wire technique can be extended to aid in design of potted components in which several different insert

REVERE COPPER EXTRUSION shown attached to skirtboard before full assembly, which you can see below in exploded view. A matching bar, similar to the one shown is part of the "packaged" HANCO unit and is fastened to the opposite side of the screen. Units, in turn, are installed on the various types of Vibrating Screens made by HEWITT-ROBINS INC., Passaic, N. J., and are known as the HEWITT-ROBINS HANNON Electric Screen Heaters.

CLOSE-UP showing end of the Revere Copper Extrusion.

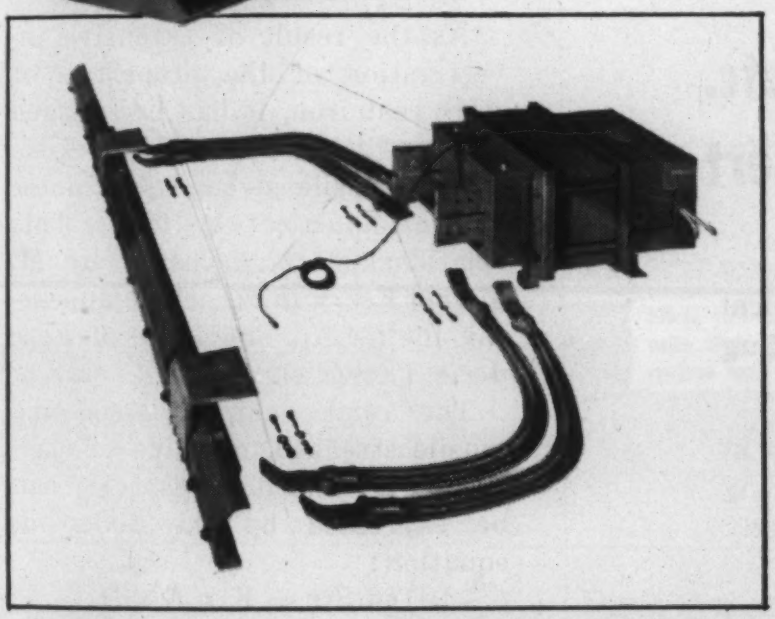
Revere Copper Extruded Shape

in Hanco Electric Screen Heater

out-performs

former copper casting

on 4 counts



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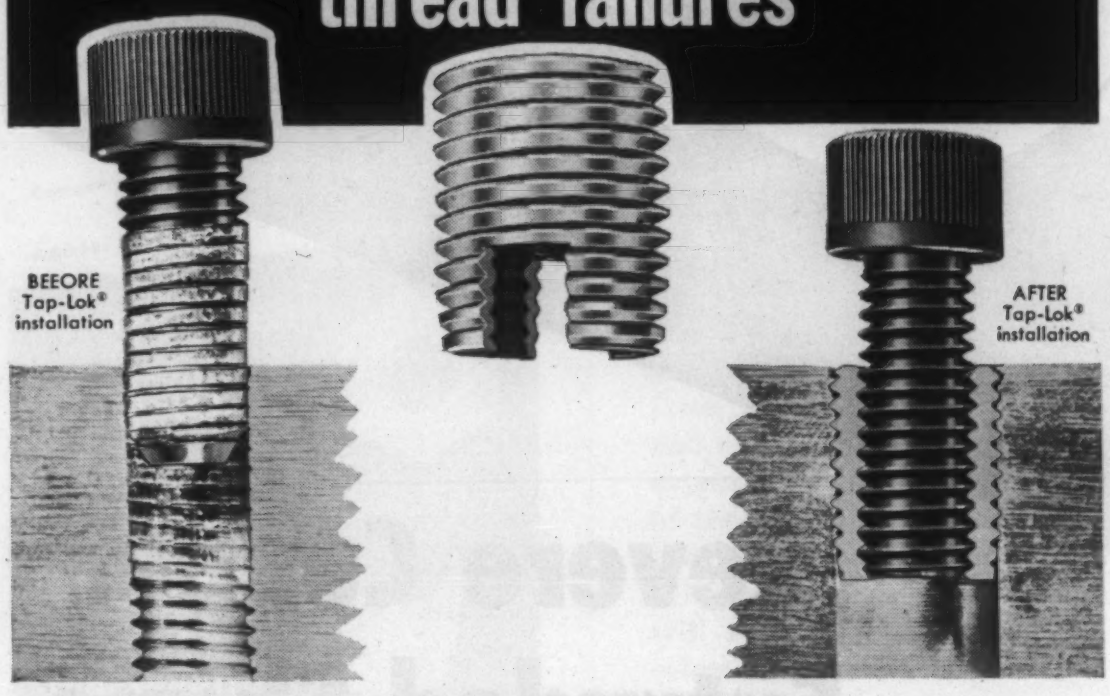

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materials must be used, each with a different expansivity. Using the same basic technique, wires can be placed in various locations in the casting to measure temperature distribution, and in areas most susceptible to cracking.

The painted circuit technique can be applied where other test methods are impractical, since such a circuit can be applied to any insulating surface without causing strains. Also, temperature gradients across resin castings can be determined by casting the piece in layers and painting the surfaces of each layer with the conductive paint.

Gray Iron Properties Can Be Calculated

As the result of extensive investigation of the properties of gray cast iron, it has been found that a simple relationship exists among tensile strength, hardness and modulus of elasticity. This relationship is discussed by M. Michel Ferry in an article appearing in the Apr '56 issue of *Fonderie* (French).

The relationship between the tensile strength, modulus of elasticity (E) and hardness (H) can be expressed by the following equation:

$$\text{Ten Str} = K \times E \times H$$

Experience has shown that the dispersion is about $\pm 10\%$, i.e., the value of tensile strength determined by this equation does not differ, in general, by more than 10% from the experimental value.

In low-phosphorus lamellar gray cast irons, the coefficient K is practically constant at 10×10^{-6}. This permits calculation of tensile strength, modulus of elasticity or hardness if any two of these values are known. For malleable cast iron and nodular cast iron the coefficient is somewhat higher —of the order of 16 to 17×10^{-6}.

As a first approximation it can be said that if H in the equation is a measure of the strength of

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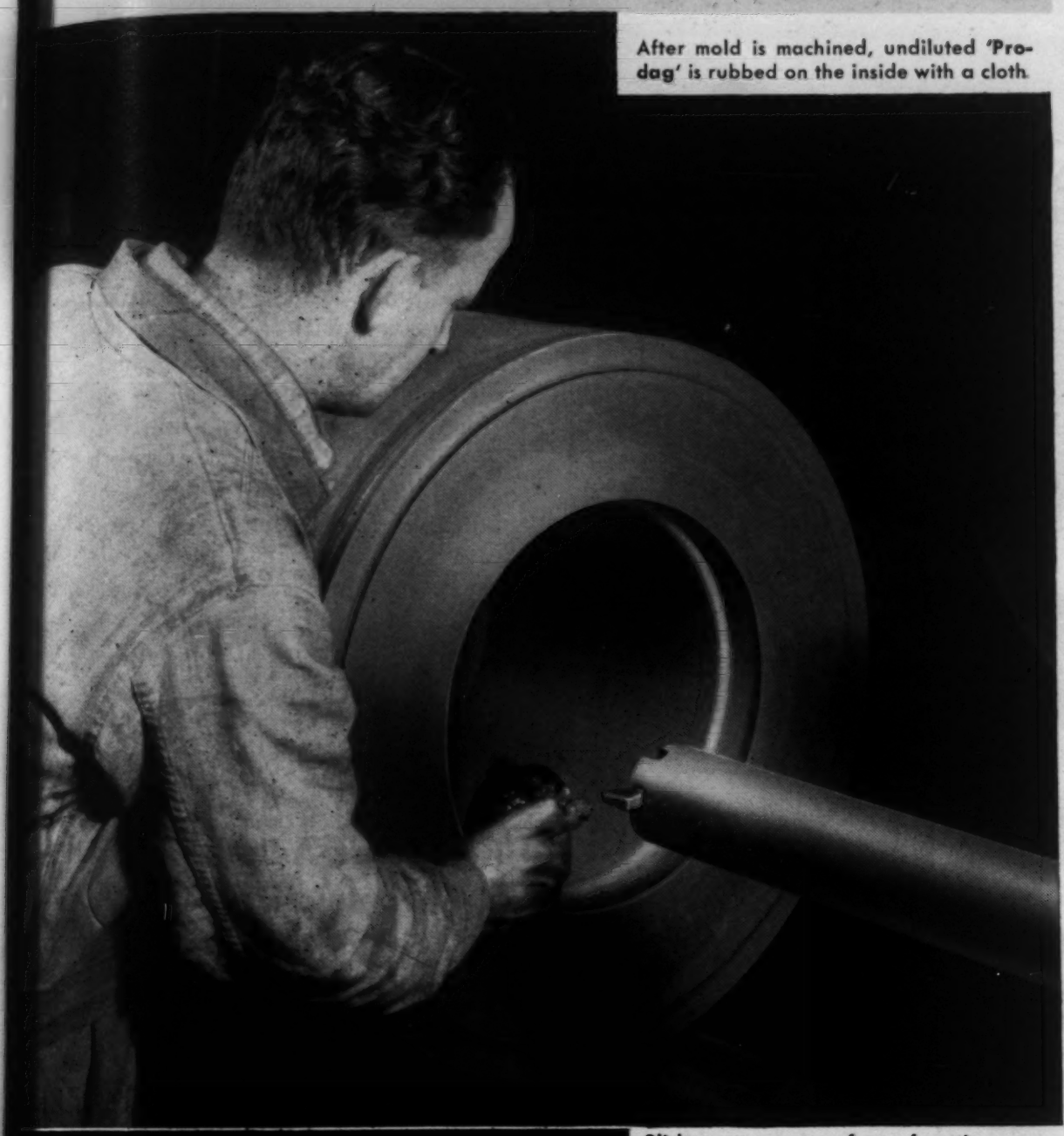
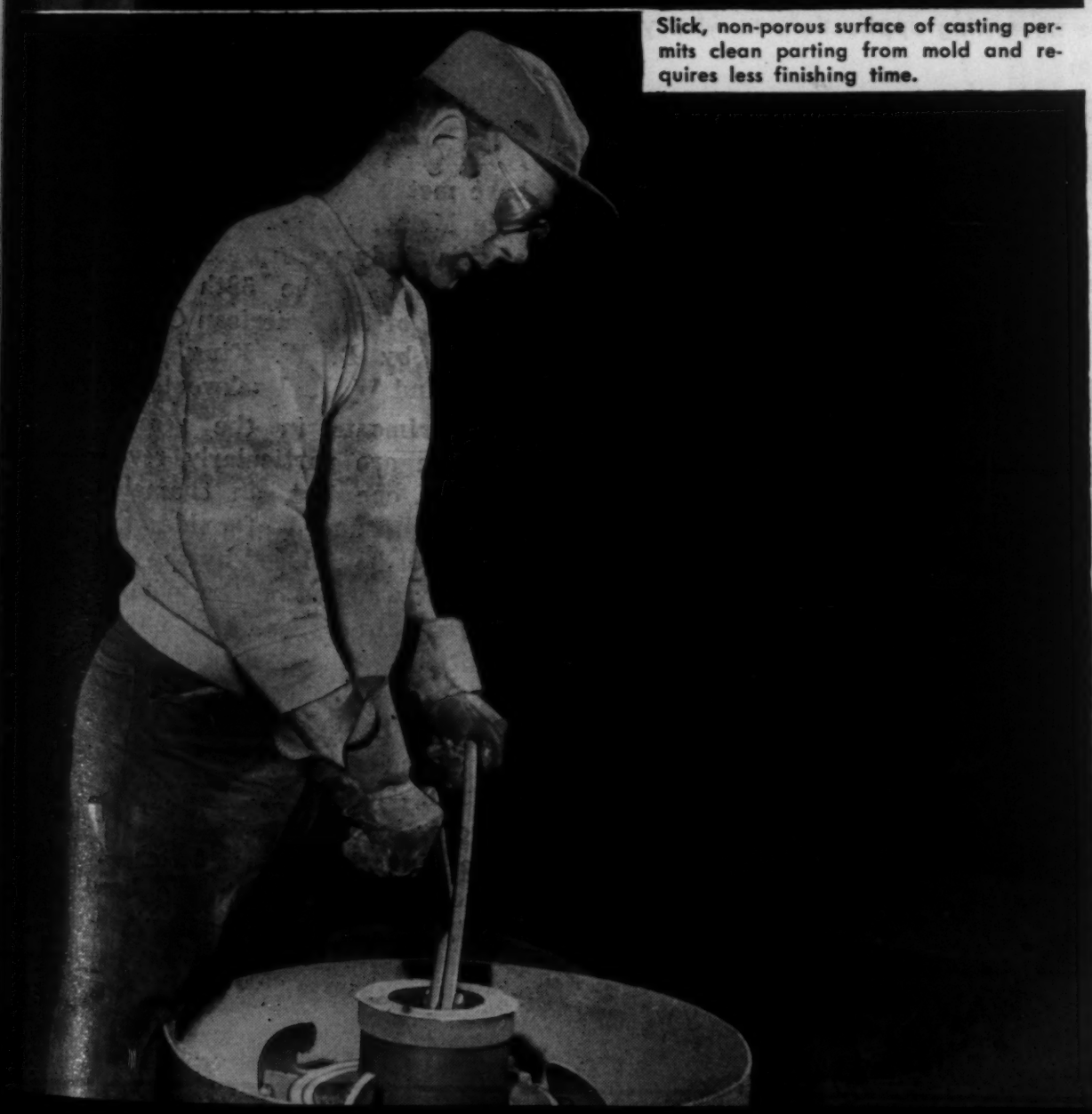
'dag' dispersions... *a touch does so much!*



After mold is machined, undiluted 'Prodag' is rubbed on the inside with a cloth.



Slick, non-porous surface of casting permits clean parting from mold and requires less finishing time.

"Mold treatment with 'Prodag' for better products at low cost."

says Wisconsin Centrifugal Foundry

Wisconsin Centrifugal Foundry casts sleeve-type brass bearings in graphite molds. Castings range from 2 inches to 30 inches in diameter; pouring temperatures from 2,000 to 2,200°F. This company has found that a single application of undiluted **'Prodag'**, rubbed into the mold, lasts for entire production runs of certain items. Molten metal does not adhere to the inside surface, so castings part easily. Less time is required for finishing, so rejects are fewer. **'Prodag'** helps Wisconsin Centrifugal turn out a better product at a lower cost.

'Prodag' and other Acheson dispersions have become indispensable for many foundry applications because of their remarkable properties under the most severe conditions. Acheson Service Engineers will be glad to give you specific information on the use of **'dag'** dispersions for mold coatings, maintenance lubrication, and other applications. No obligation, of course.

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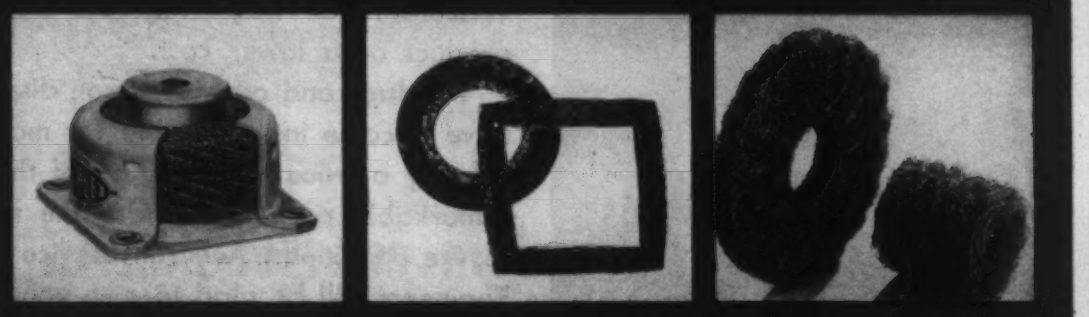

If you haven't started to investigate the design potential for knitted stainless steel and nickel alloy wire, now is the time to do it. Here are some interesting applications to whet your interest and imagination:

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2. **ELECTRONIC SHIELDING**—knitted alloy wire gaskets eliminate radio interference in electronic equipment. Nickel alloy wire has good conductivity, corrosion resistance and resiliency.
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Prospect Park, Pennsylvania

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the matrix, E is a coefficient which indicates the form and quantity of the graphite present. K is a coefficient indicating the notch effect of the form in which the graphite exists in the matrix.

Compared with a steel having the same matrix, a rough approximation of the notch effect is obtained from the reduction in tensile strength. Thus the strength of nodular iron is 5% lower; of malleable iron, about 5 to 10% lower; of gray iron with a structure consisting of pearlite and lamellar graphite, 35 to 50% lower; and of gray iron with a structure consisting of ferrite and lamellar graphite, 20 to 40% lower.

Improving Adherence of Porcelain Enamels

To achieve good adherence of porcelain enamel to metal it is essential that: 1) the enamel at the metal-enamel interface be saturated with an oxide of the base metal, and 2) this oxide be one which, when in solution in the enameling glass, will not be reduced by the metal. These conditions were deemed essential in research tests conducted with 26 base metals by ceramists of Battelle Memorial Institute. Results of this study were presented in a paper before the 58th Annual Meeting of the American Ceramic Society by B. W. King, H. P. Tripp and W. H. Duckworth.

Experiments in the research program are particularly revealing. In one test, an enameling glass compounded of oxides that would not be reduced by the base metal was melted on the metal in a neutral atmosphere. Under these conditions, the glass would not wet the metal and remained in a ball. No adherence developed. However, when oxygen was made available—either from the atmosphere or by including a reducible oxide in the glass batch—it formed an oxide with the base metal, promoted wetting, and en-

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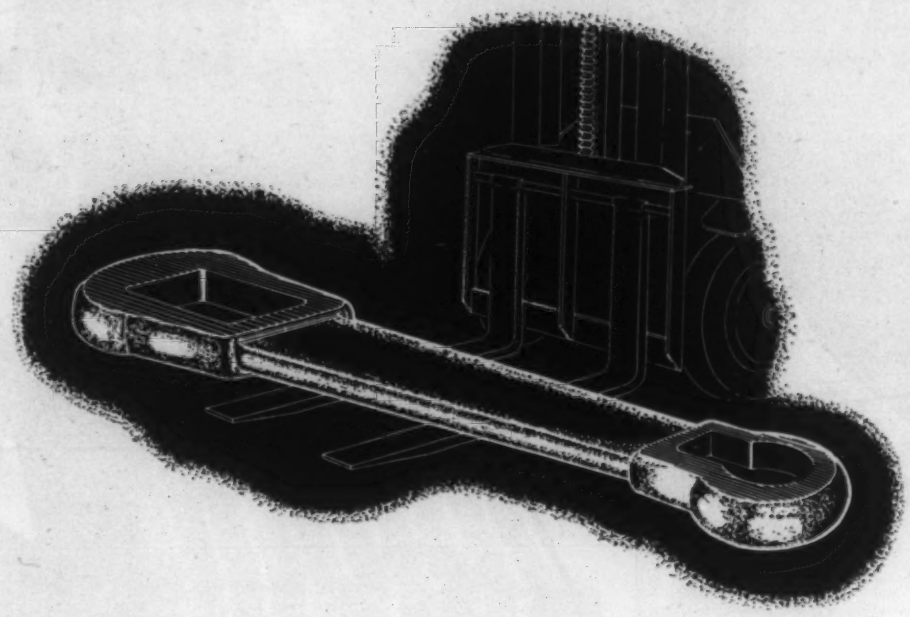

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abled the glass to spread in a layer on the metal. When the molten glass had dissolved enough of the base metal oxide to become saturated, good adherence of the glass layer was obtained.

In another experiment, excellent adherence was obtained on a smooth, clean metal surface by initially saturating the glass with the proper oxide. In this case, electropolished iron was enameled in an argon atmosphere with a glass saturated with ferrous oxide (FeO). Research also demonstrated that adherence is destroyed when ferrous oxide, or the appropriate oxide for the particular metal, diffused away from the surface. This loss in adherence occurred even when the interface was very rough.

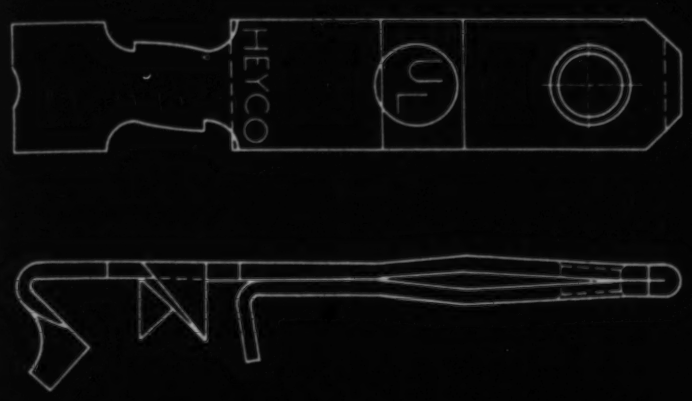
Experiments suggest that good adherence is largely a chemical phenomenon. Even though interfacial roughness provides a greater specific surface area and, in some cases, mechanical keying, it is not the necessary condition for a good bond.

The function of adherence-promoting oxides of cobalt and nickel was also determined. During early stages of firing the oxides aid in scale removal by converting iron-deficient, crystalline FeO scale (wustite) into Fe_3O_4, which dissolves more rapidly in enamel than does wustite. Also, cobalt and nickel oxides, which have more than one normal valence state, can supply some of their oxygen at the interface, thus promoting adherence.

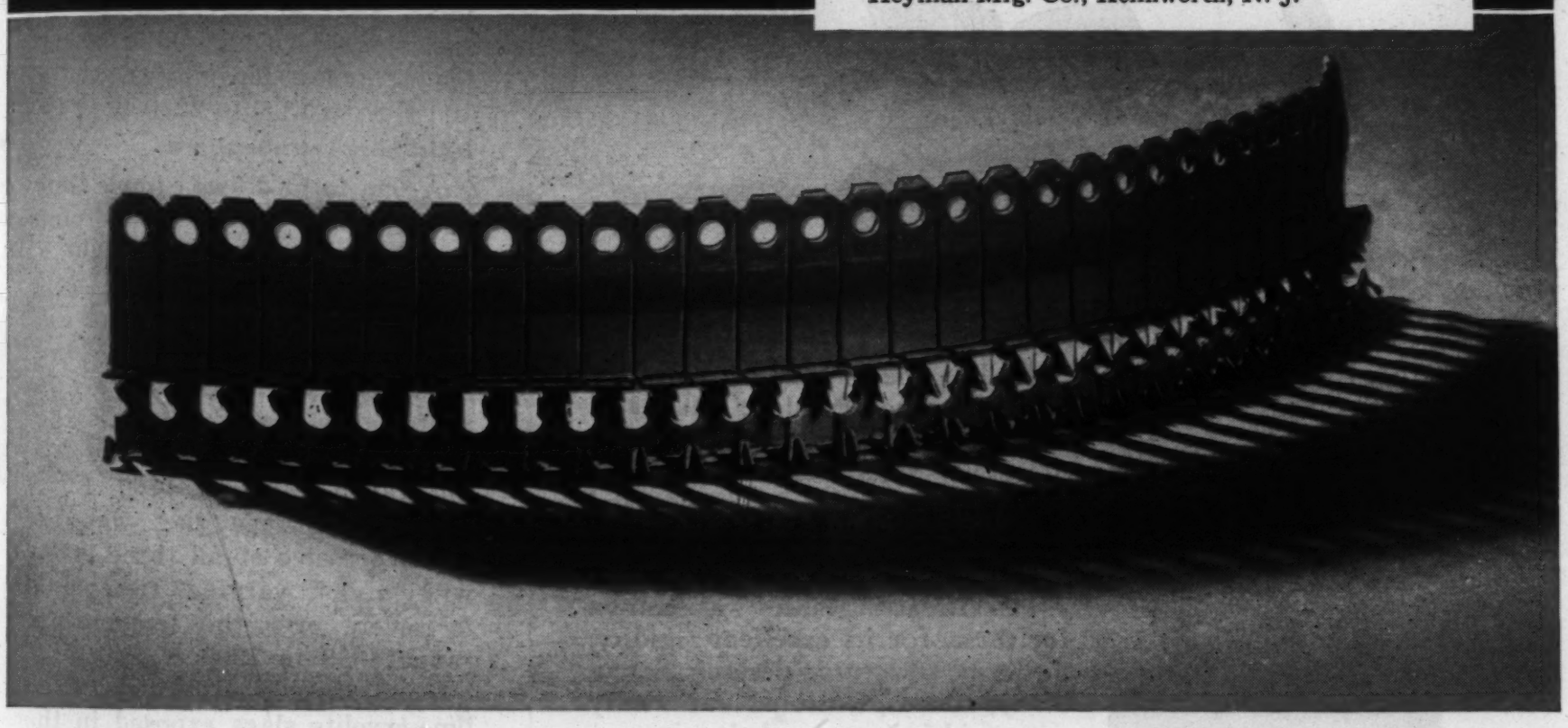
How Welding Slags Influence Corrosion

Welding slag residues can shorten the useful life of nickel-chromium-iron alloys used at high temperatures. Corrosive attack can be expected at any temperature above 1200 F—by oxidation in oxidizing atmospheres or by sulfidation in reducing atmospheres. In an article in the Sept '56 issue of the *Welding Journal*,

Matching metal to job with Bridgeport alloys



Brass blades for electric plug caps are stamped from Bridgeport Cartridge Brass, Alloy #69 for positive contact and long service. Made by Heyman Mfg. Co., Kenilworth, N. J.



For fast, close-tolerance stamping and forming specify Bridgeport HIGH I.Q.* Strip

Stamping brass plug blades like these on special presses with multiple station dies calls for the right combination of methods and material. The material used must have exact temper and ductility for clean cuts and accurate forming and bending through 180°. That's why Bridgeport Alloy #69 was specified —it was *matched* to the job, for manufacturing requirements as well as for the finished product.

Stamped or machined—there's a Bridgeport High I.Q.* Alloy that will help you cut production costs and produce a better product. Call your nearest Bridgeport Sales Office today. They'll give you the metal that's *job-matched* to your requirements.

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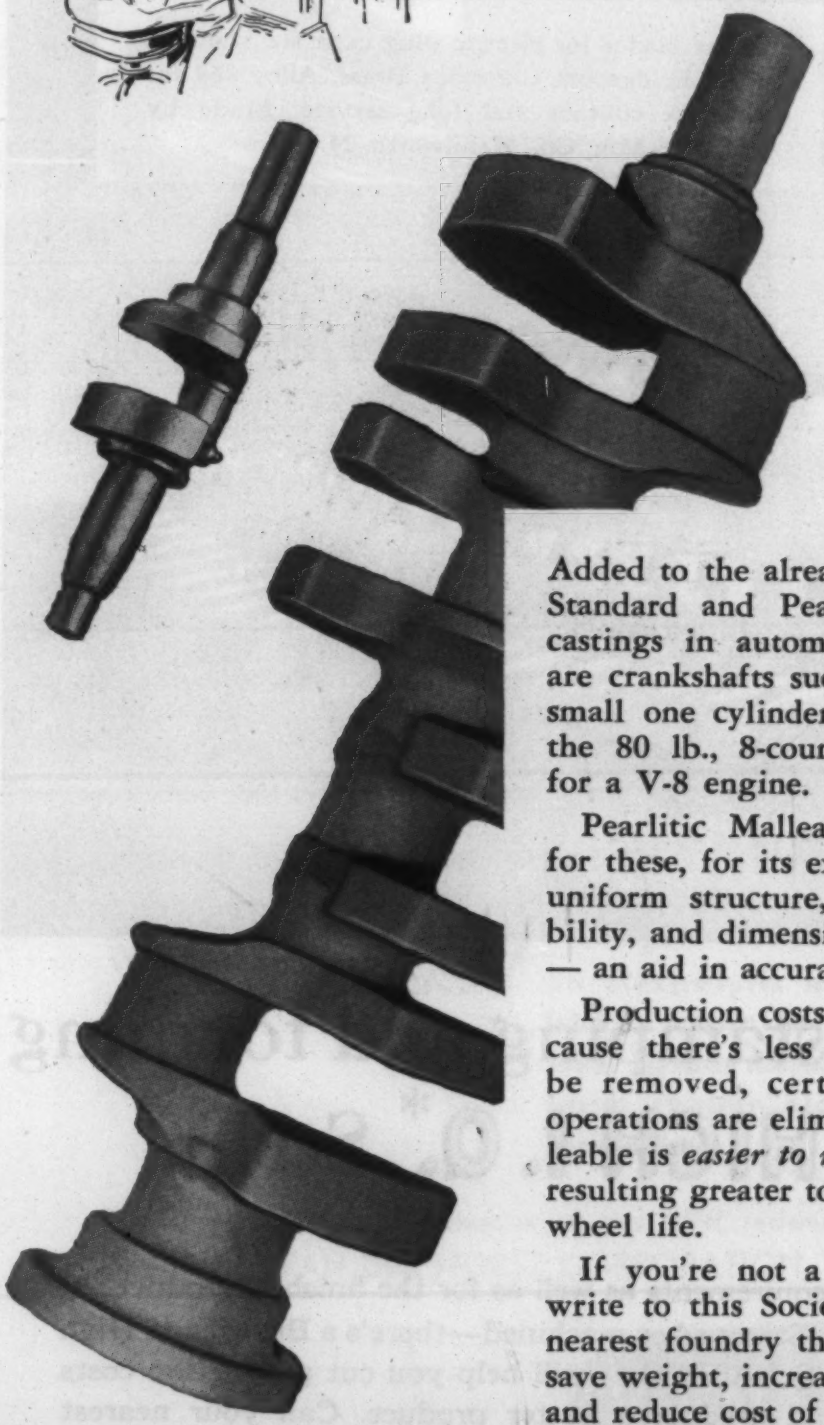
Another vital automotive component "goes Malleable"



Added to the already broad use of Standard and Pearlitic Malleable castings in automotive assemblies are crankshafts such as these — a small one cylinder 3-pounder and the 80 lb., 8-counterweight shaft for a V-8 engine.

Pearlitic Malleable was chosen for these, for its excellent rigidity, uniform structure, design adaptability, and dimensional uniformity — an aid in accurate balancing.

Production costs are reduced because there's less excess stock to be removed, certain machining operations are eliminated and malleable is *easier to machine* — with resulting greater tool and grinding wheel life.

If you're not a malleable user, write to this Society for name of nearest foundry that can help you save weight, increase dependability and reduce cost of many parts.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building — Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 443

CONTENTS NOTED

G. R. Pease describes what is likely to happen to nickel-chromium-iron alloys if placed in high temperature service while contaminated with welding slag residues.

Slags formed by three substantially different welding electrode compositions were selected for study. Test specimens were prepared by depositing weld beads on small pieces of Inconel, Inconel X and Inconel W sheet, providing nine combinations of slag and base metal. The slag was left intact after welding, and the test specimens were exposed at 10 test temperatures in increments of 100 F from 1300 to 2200 F.

Oxidizing atmosphere

A slag formed by a simple lime-fluorspar type of flux was found to be very corrosive at 2200 F, less corrosive from 1800 to 2100 F, and practically noncorrosive at lower temperatures. A lime-cryolite-rutile type slag was erratic in its behavior and was suprisingly corrosive at temperatures in the range 1400 to 1700 F. A lime-cryolite type slag was the most corrosive of all three types, with attack varying from mild to severe over the temperature range 1300 to 2200 F.

The lime-cryolite-rutile and lime-cryolite slags exposed in the range 1300-1700 F became yellow during test, and there was a yellow water-soluble residue present even after persistent brushing. The yellow substance was presumed to be a chromate salt of some sort, the formation of which may account for the unexpectedly rapid rate of attack in this temperature range.

Reducing atmosphere

Slags were also exposed at 1500 F in a hydrogen atmosphere containing 0.01% hydrogen sulfide—less than many low-sulfur heat treating atmospheres. Exposure period was 1 mo and rate of gas flow was about 3 cfh. It was found that three of four slags exposed absorbed sulfur in the damaging sulfide form. The rutile-containing slag, the only one which picked

Brush wire, crimped (as shown) or straight, now produced in multiple strand, and furnished in coils or straight banks depending on wire size.

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CONTENTS NOTED

up no sulfur in the test, was later shown to be capable of absorbing sulfur from a hydrogen atmosphere containing hydrogen sulfide at 10 times the previous level.

The results indicate that 1) the rutile type of flux is not immune to sulfur attack, and 2) the high fluoride types are the most susceptible to sulfur absorption. The limiting service temperature for slag-contaminated weldments in reducing atmospheres is governed by the temperature above which sulfur attack is likely. In the case of chromium-bearing high nickel alloys, sulfidation can be experienced at temperatures as low as 1200 F.

Measuring Thickness of Hollow Parts

A nondestructive capacitance test method for measuring wall thickness from one side of such hollow items as extruded plastic tubes and complicated blown glass devices is described in the Nov '55 issue of *Revue francaise des corps gras* (French).

The apparatus is a special capacitometer which measures variations in capacity between two electrodes resting on the material. The base electrode consists of a central disk and six small, ball joint-mounted, spring cushioned disks around it. The other electrode is held in a handle and is shaped to match the piece being tested. The apparatus is calibrated for a given insulating material.

Capacitance is dependent on the electric field distribution set up by the two electrodes and is modified by the presence of an insulating material proportionately to its distribution (thickness, etc.) and its dielectric constant.

The instrument is accurate within 5%, this degree of possible error being due to variations which may occur in the conditions of application or to lack of homogeneity in the part being tested.

(Books on p 222)

HYSOL
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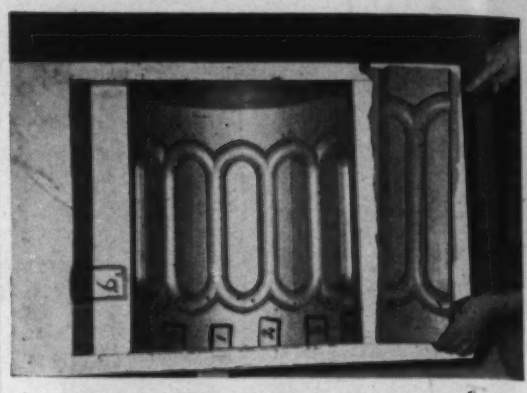
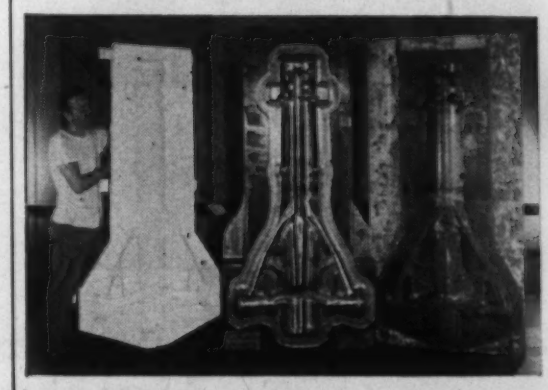
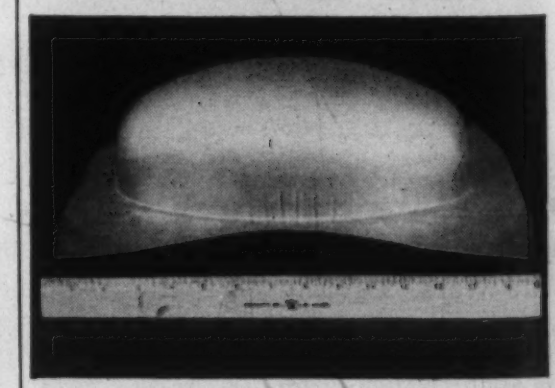


• KELLER PATTERNS •



• DIE FORMED PART •



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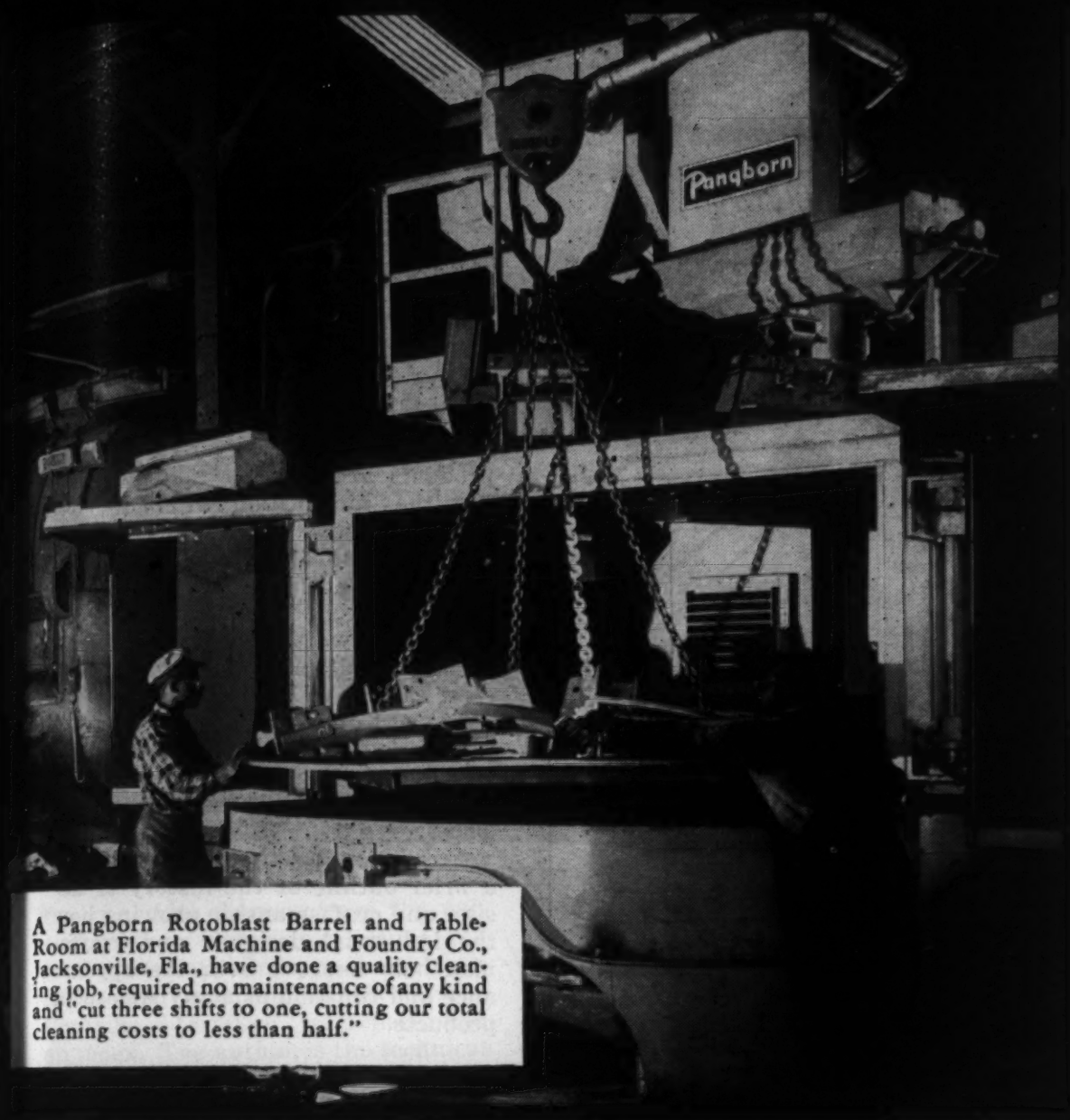

A Pangborn Rotoblast Barrel and Table-Room at Florida Machine and Foundry Co., Jacksonville, Fla., have done a quality cleaning job, required no maintenance of any kind and "cut three shifts to one, cutting our total cleaning costs to less than half."

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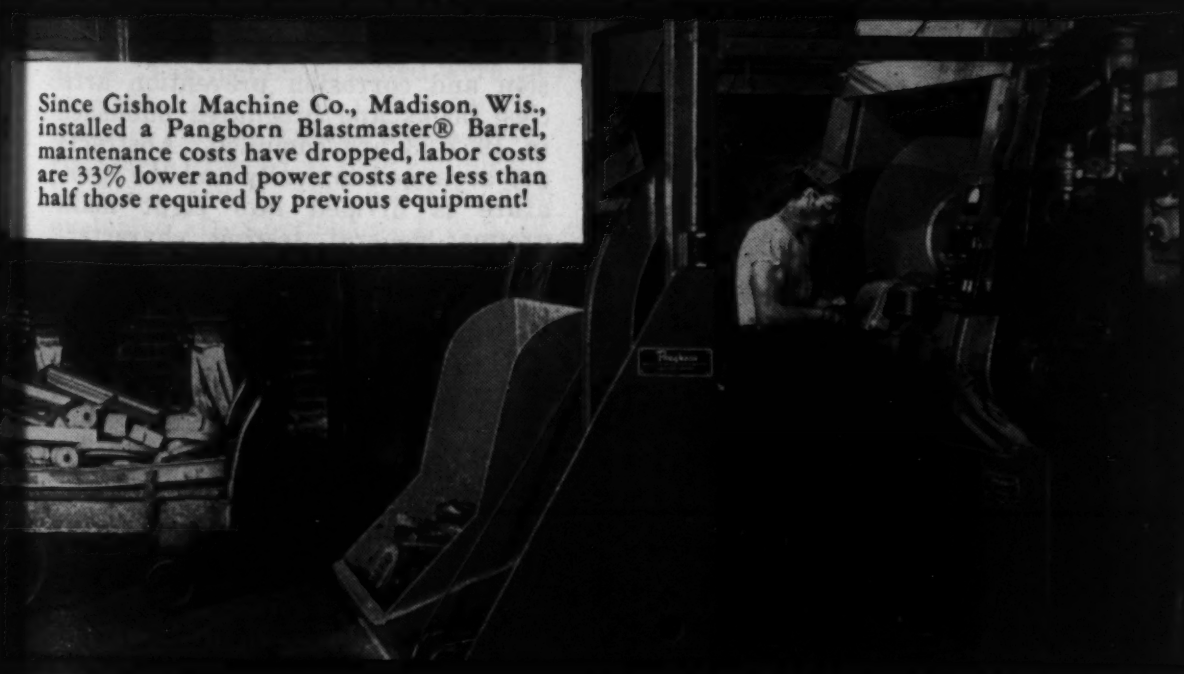
And cuts maintenance, labor and power costs at Gisholt!



Since Gisholt Machine Co., Madison, Wis., installed a Pangborn Blastmaster® Barrel, maintenance costs have dropped, labor costs are 33% lower and power costs are less than half those required by previous equipment!

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8-8

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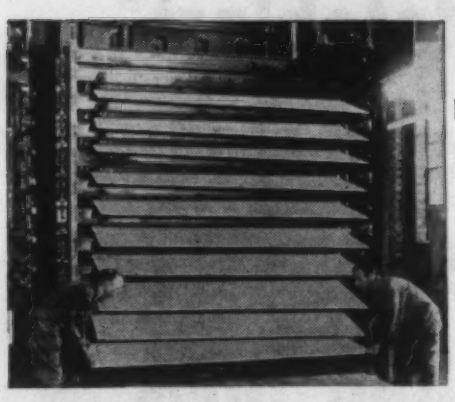
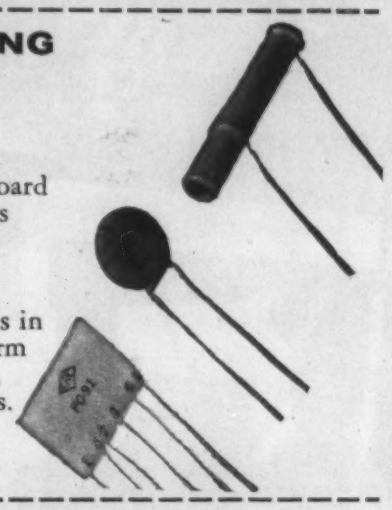


Wood particles are bonded into durable board and molded products with Durez resins.

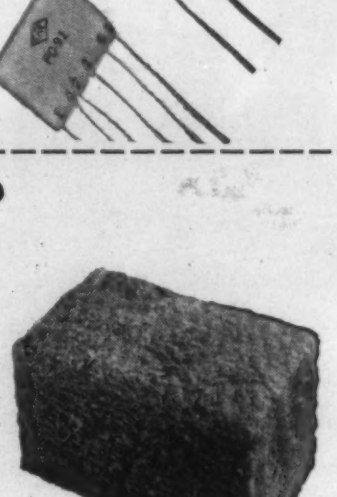
In electronics, resins in dip compounds form tough, dust-proof, heat-resistant coatings.



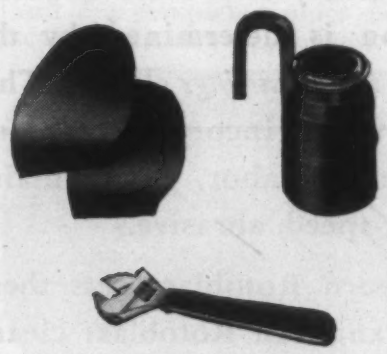
● **HOT...OR COLD**

Braking generates heat, but the resin bond in linings prevents "fading", adds wear.

In refrigerator insulation, a protective bond of resin safeguards batts from moisture.



● **RESILIENT...OR HARD**



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...do these suggest benefits for your business?

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For more information, turn to Reader Service Card, Circle No. 405

CONTENTS NOTED

BOOKS

Shaping America's Products. *Don Wallance. Reinhold Publishing Corp., New York 22, N.Y. Cloth, 8¼ by 10½ in., 198 pp. Price $10.*

This book, using 31 detailed case studies, shows how well-designed products are meeting and overcoming the competition of badly designed objects or those that can hardly be said to have been designed at all. The author, who has designed such varied items as bathroom fixtures, a new type of folding chair in metal and plastics, and stainless steel tableware (the origins and development of which are described in this book) obtained his material by actually visiting scores of factories, workshops and industrial design offices.

Accompanying the case studies is a brief outline of the history of design and craftsmanship showing how the industrial designer and craftsman help improve both the appearance and function of many American products.

Bibliographic Survey of Corrosion: 1952-53. *Compiled by A. Irene Humphrey. Available from National Association of Corrosion Engineers, 1061 M&M Bldg., Houston 2, Tex. Cloth, 382 pp., 8½ by 11 in. Price $12.50.*

This is the fifth in a series of NACE bibliographies on corrosion literature. Summaries of 3344 corrosion and corrosion prevention articles, books and brochures published in 1952-53 are compiled. Abstracts are arranged topically and the literature is divided into eight main groups; general, testing, characteristic corrosion phenomena, corrosive environments, preventive measures, materials of construction, equipment and industries. The subject index lists many metals and alloys by trade name and indexes them as to specific properties and behavior in specific media. An author index is included.

Radioisotopes — The Wonder Tool. *Edited by Walter A. Shead. Callahan & Hollowell, Evans Bldg., Washington 5, D.C. Paper, 92 pp., 8¼ by 10¾ in. Price $7.50.*

Case histories and specific methods by which 28 industries are using radioisotopes in automatic process control are described. More than 1100 examples are cited. Some industries listed in the book are: adhesives, aluminum, ceramics, copper-brass, paper, plastics, rubber, steel and textiles. Includes a discussion of industrial radiography, a description of the most commonly used

For more information, Circle No. 594

BOOKS

atomic instruments and their functions, and a glossary of atomic terms. Also contains directories of companies making atomic instruments, companies making isotope labeled compounds, and firms offering waste disposal service.

Latex: Natural and Synthetic. *Philip G. Cook. Reinhold Publishing Corp., New York 22, N.Y. 1956. Cloth, 4¾ by 7 in. 236 pp. Price $3.50.*

This book shows how both natural and synthetic types of rubber latex are produced, modified and finally converted into useful products. It is intended for newcomers in the latex field as well as those in allied industries. Also discussed are the vulcanization of latex, processing and testing of compounds, rubber-plastic latices and synthetic rubber latices. Contains literature references and an index. The author is the technical superintendent of the General Latex & Chemical Corp., Cambridge, Mass.

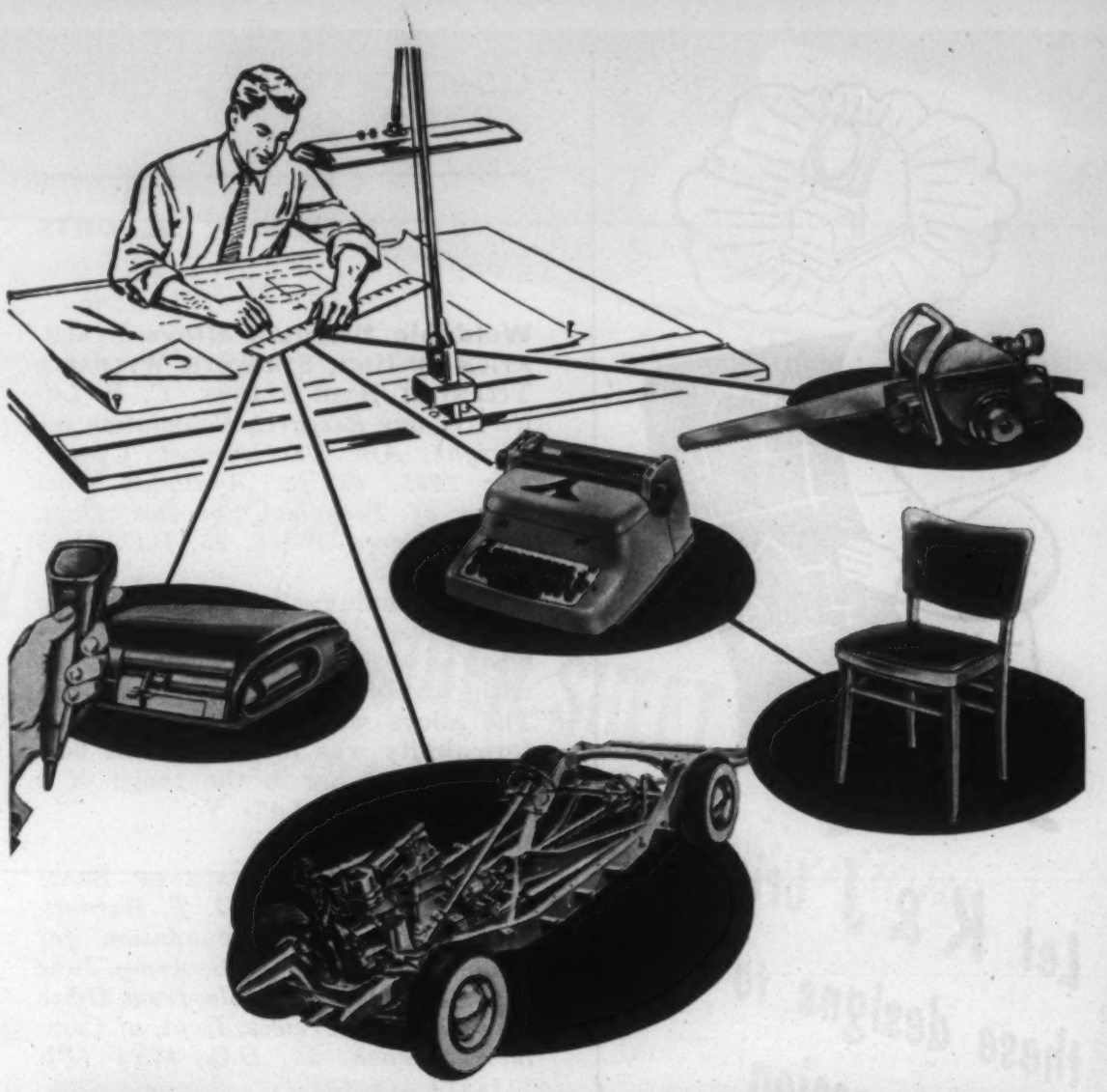
Symposium on Atmospheric Corrosion of Non-Ferrous Metals. *American Society for Testing Materials, Philadelphia 3, Pa. 1956. Paper, 6 x 9 in. 168 pp. Price $2.75.*

This symposium covers the measurement of atmospheric corrosion properties of nonferrous metals and alloys. The materials tested were 24 wrought alloys of zinc, nickel, copper, lead, tin and aluminum. These materials were exopsed at nine significant localities across the country and evaluated after periods of 1, 3, 6, 10 and 20 years, embracing about 9000 test specimens.

Casting Kaiser Aluminum. *Kaiser Aluminum & Chemical Corp., Chicago 11, Ill. 1956. Coth, 5½ x 7½ in. 386 pp.*

This book deals with foundry practices employed in casting aluminum. Data is given on the sand, permanent mold, die, shell mold, centrifuga, investment and paster processes. Each method is evauated with a listing of advantages and distadvantages together with operational techniques employed. Specific data are included on aluminum-copper alloys as we as on auminum-tin, aluminum copper siicon and aluminum siicon copper alloys. Such subjects as designing for auminum castings, heat treating, inspection, finishes and salvage are also discussed. Ilustrated with photographs, drawings and graphs, the book aso contains a dictionary of words and terms comcon to aluminum casting.

(Reports on p 226)



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CONTENTS NOTED

REPORTS

Weldable titanium alloys EVALUATION OF HIGH STRENGTH WELDABLE TITANIUM BASE ALLOYS. *C. R. Lillie. Armour Research Foundation for Wright Air Development Center. Dec 1955. 62 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.75 (PB 121069)*

Six titanium-aluminum-vanadium alloys were investigated for suitability as high strength weldable sheet with utility at high temperatures. The alloys were weldable and good formability was indicated. The best compositions lay in the range of 4 Al-4% V to 6 Al-4% V.

Brazing FUNDAMENTALS OF BRAZING. *N. Bredzs and O. T. Barnett. Armour Research Foundation for Frankford Arsenal, U.S. Army. June 1954. 162 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $4.25 (PB 111697)*

Describes two fundamental investigations. The first is concerned with the causes and elimination of imperfections in brazed joints, with specific study of the wettability phenomenon and the mechanism involved. The second deals with tensile strength-joint thickness curves for pure silver and pure copper brazed in SAE 1020 steel and drill rod. A new brazing method characterized by complete diffusion of filler metal into adjacent layers of the base metal was developed.

Low temperature properties CONFERENCE ON MATERIALS AND DESIGN FOR LOW TEMPERATURE SERVICE. *Engineer Research and Development Laboratories, U.S. Army. Aug 1956. 400 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $10 (PB 121009)*

Background guide for designers and fabricators of low temperature equipment. Contains pre-1952 data on low temperature properties of metals and an extensive bibliography. The book is said to be one of the few comprehensive collections of material on the subject of low temperature properties of metals.

Modified chromium steels INVESTIGATION OF MODIFIED 12% CHROMIUM STEELS FOR INTERMEDIATE TEMPERATURE APPLICATIONS. *P. Shahinian and J. R. Lane, Naval Research Laboratory. Apr 1956. 26 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 75¢ (Available also on micro-*

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INVESTMENT CASTINGS

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CONTENTS NOTED

REPORTS

card from Photoduplication Service, Library of Congress, Wash. 25, D.C. $1.80)

Describes creep-rupture properties of a 12% chromium steel modified by additions of molybdenum, vanadium, columbium, titanium and carbon. Tests were conducted at 1100 and 1200 F as well as room temperature for materials as-cast, cast and homogenized, forged and normalized, and tempered. A chromium steel modification containing 1.0 molybdenum and 0.7% vanadium showed creep-rupture properties that compared favorably with those of the best of the columbium-free alloys developed so far.

Hydraulic seals EVALUATION OF HIGH TEMPERATURE HYDRAULIC SEALS. *E. A. Webster, Douglas Aircraft Co., Inc., Jan. '55. 107 pp, illus. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Film $5.70, photo $16.80. (PB 120264)*

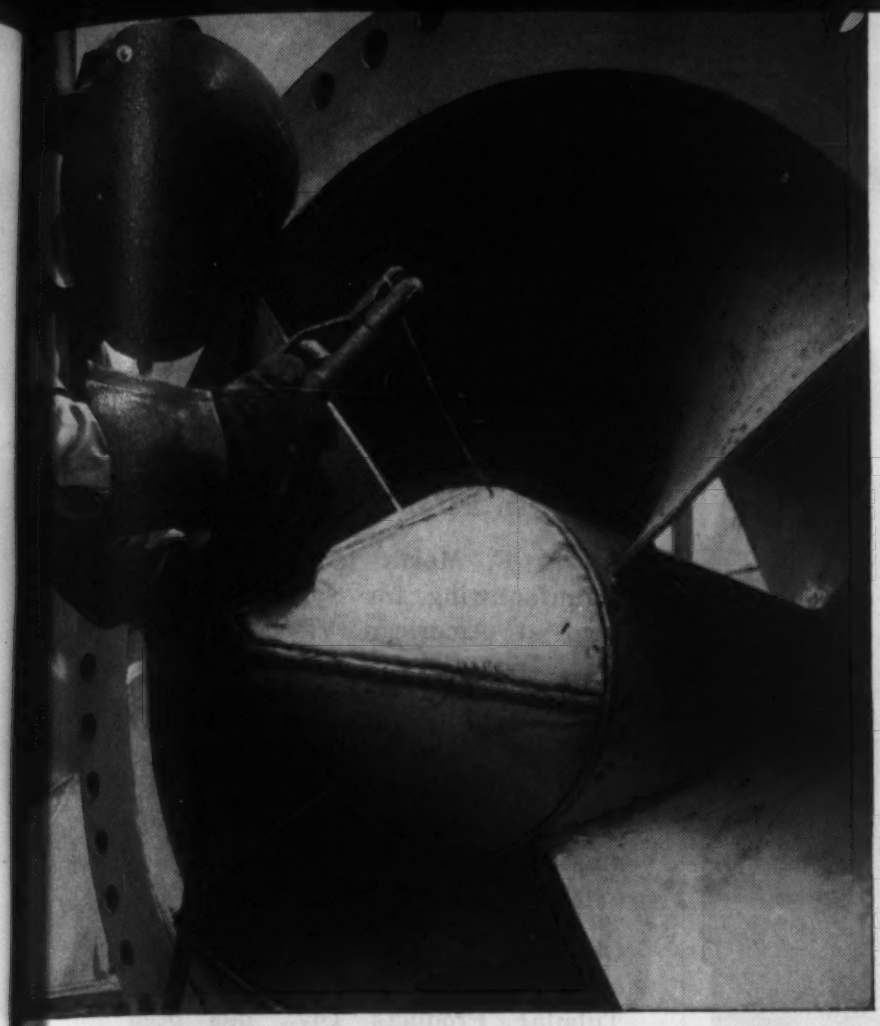
Temperature limitations of approved AN 6227 o-rings and AN 6246 leather back-up rings; comparative qualification tests of all currently available experimental high temperature o-ring materials; evaluations of various experimental seal configurations; and tests of back-up materials and configurations for high temperature use.

Ozone cracking of rubber OZONE CRACKING OF SYNTHETIC AND NATURAL RUBBER SHEET MATERIALS. *A. Baker and A. J. Woods, Royal Aircraft Establishment, England. Apr '49. 10 pp, illus. Available from Library of Congress, Photoduplication Service. Publications Board Project, Wash. 25, D.C. Film $1.80, photo $1.80 (PB 120155)*

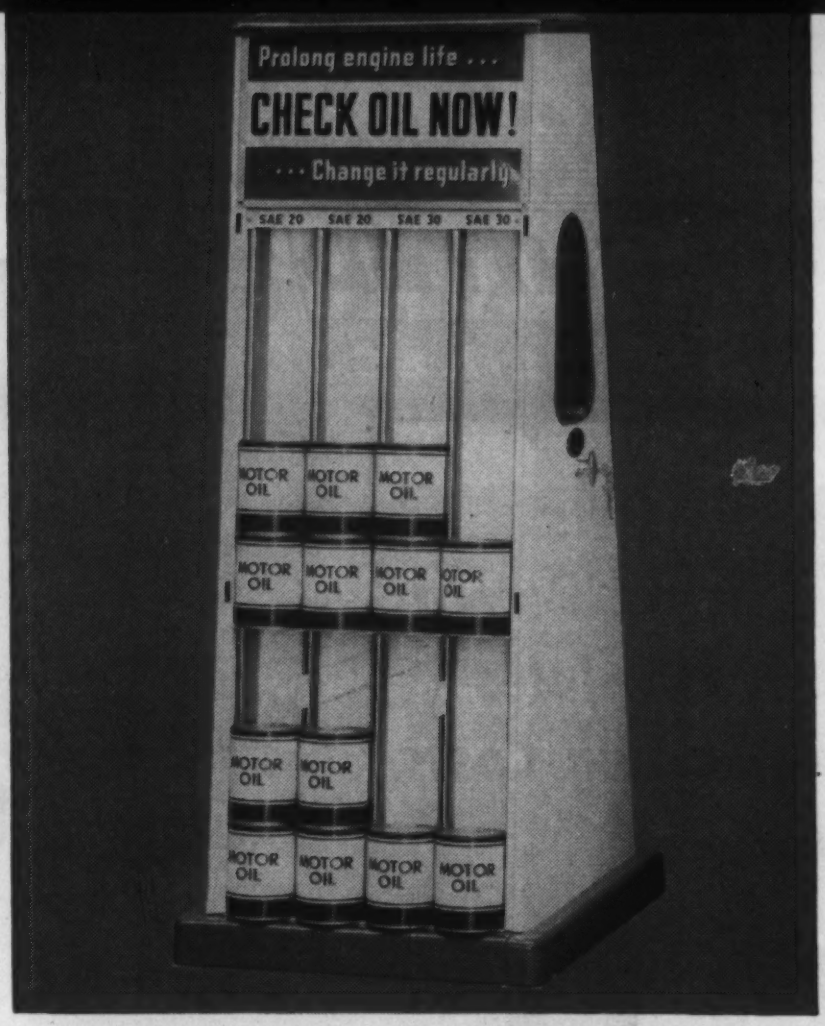
It was found that plasticizer has a significant effect in promoting the cracking of stressed synthetic rubbers by ozone. A specification test method for assessing ozone resistance of rubbers is proposed.

Phosphated Steel CORROSION RESISTANCE OF PHOSPHATED STEEL AFTER HEATING UNDER OIL. *Jodie Doss, U.S. Arsenal, Rock Island, Ill., Aug '55. 14 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 50¢. (PB 111915)*

Zinc and manganese phosphate coatings were heated under oil at 25-deg intervals in the range of 175 F through 450 F.



FOR COMPLEX FABRICATION. In chemical plants, these Stainless Steel acid catchers are used to remove dilute sulfuric acid from gases. Continental Boiler & Sheet Iron Works in St. Louis fabricated the units. Notice the complicated curves in the helix plates, and the neat joinery . . . a tribute to fine craftsmanship and the workability of Stainless Steel.

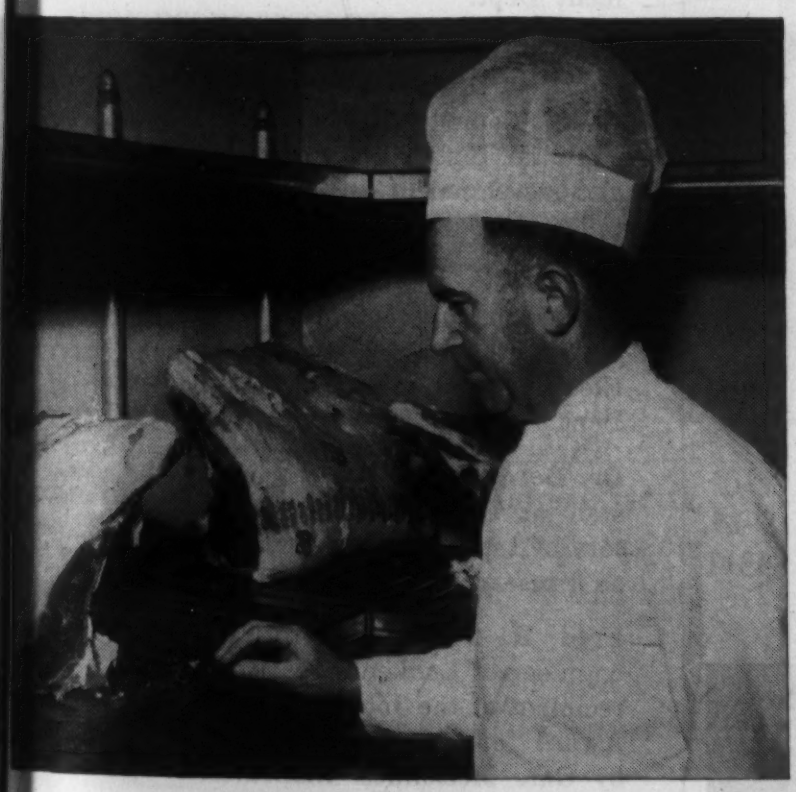


FOR ABRASION AND CORROSION RESISTANCE. Oil can racks stand out in all kinds of weather, and the support strips are constantly rubbed and knocked by the heavy cans of oil. Modern Metal Products Company of Greensboro, N. C. makes the strips out of Stainless Steel so they will stay bright and new-looking, and never get banged out of shape.

NOTHING *can equal* *Stainless Steel*

In its combination of desirable properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.



FOR SANITATION. These Stainless Steel shelves are made by the Eastern Steel Rack Company, Boston, Massachusetts, for use in cold storage rooms. They are easy to clean, and offer a sanitary, corrosion-resistant surface for food products of all kinds.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

For more information, turn to Reader Service Card, Circle No. 429

How UNITED AIR LINES

Protects Safety Record and Reduces Operating Costs with . . .

3-D Micro-Vision

At the world's largest commercial aircraft maintenance base, in South San Francisco, Bausch & Lomb Stereomicroscopes play an important part in insuring the safety and efficiency of United Air Lines planes. For 15 years inspectors have been using these optical aids for quick, sure identification of defects in cams, bearings, gear teeth, plating, connecting rods, and many other engine parts. Cracks, plating inclusions, rough surfaces which might cause wear—they all show up vividly in natural 3-dimensional detail. These critical inspections, made during regularly scheduled engine overhauls, catch failures *before* they happen. The result: dependable safety . . . lower operating cost.

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NEWS OF ENGINEERS COMPANIES SOCIETIES

William H. Graves, formerly vice president of engineering at Studebaker-Packard Corp., has been appointed to the board of directors of American Forging & Socket Co.

Edwin F. Morfit is now head of manufacturing for Sylvan Plastics, Inc., at American Viscose Corp.'s Film Div. plant at Fredericksburg, Va.

Leonard I. Meisel has transferred from the Naval Air Experimental Station to the Philadelphia Quartermaster Depot to become civilian chief of the Testing Laboratories.

G. H. Rearick, Milwaukee plant manager of Babcock & Wilcox Co.'s Tubular Products Div., has been named to the staff of W. J. Thomas, company vice president. **Norman E. Wenzel** succeeds Mr. Rearick as Milwaukee plant manager.

Ben A. Swennes is director of engineering for all products manufactured by Ingersoll Kalamazoo Div., Borg-Warner Corp.

W. S. Sherk has been made technical director of operations of Electro Metallurgical Co. to succeed **Paul McVicker** who is now general manager, Product and Process Development Dept.

Dr. Floyd A. Firestone, consulting physicist, has been awarded the Edward Longstreth Medal of the Franklin Institute for his invention and development of the ultrasonic reflectoscope.

Thomas S. Teague has been appointed manager of materials in the manufacturing section of General Electric's Metallurgical Products Dept.

Dr. Gordon E. Zima has joined the staff of Bayonne Research Laboratory of International Nickel Co., Inc., as a research metallurgist.

Fred H. Hehemann, retired chief engineer of Lunkenheimer Co., is the recipient of the John T. Faig Alumni Award for 1956, presented annually by Ohio Mechanics' Institute.

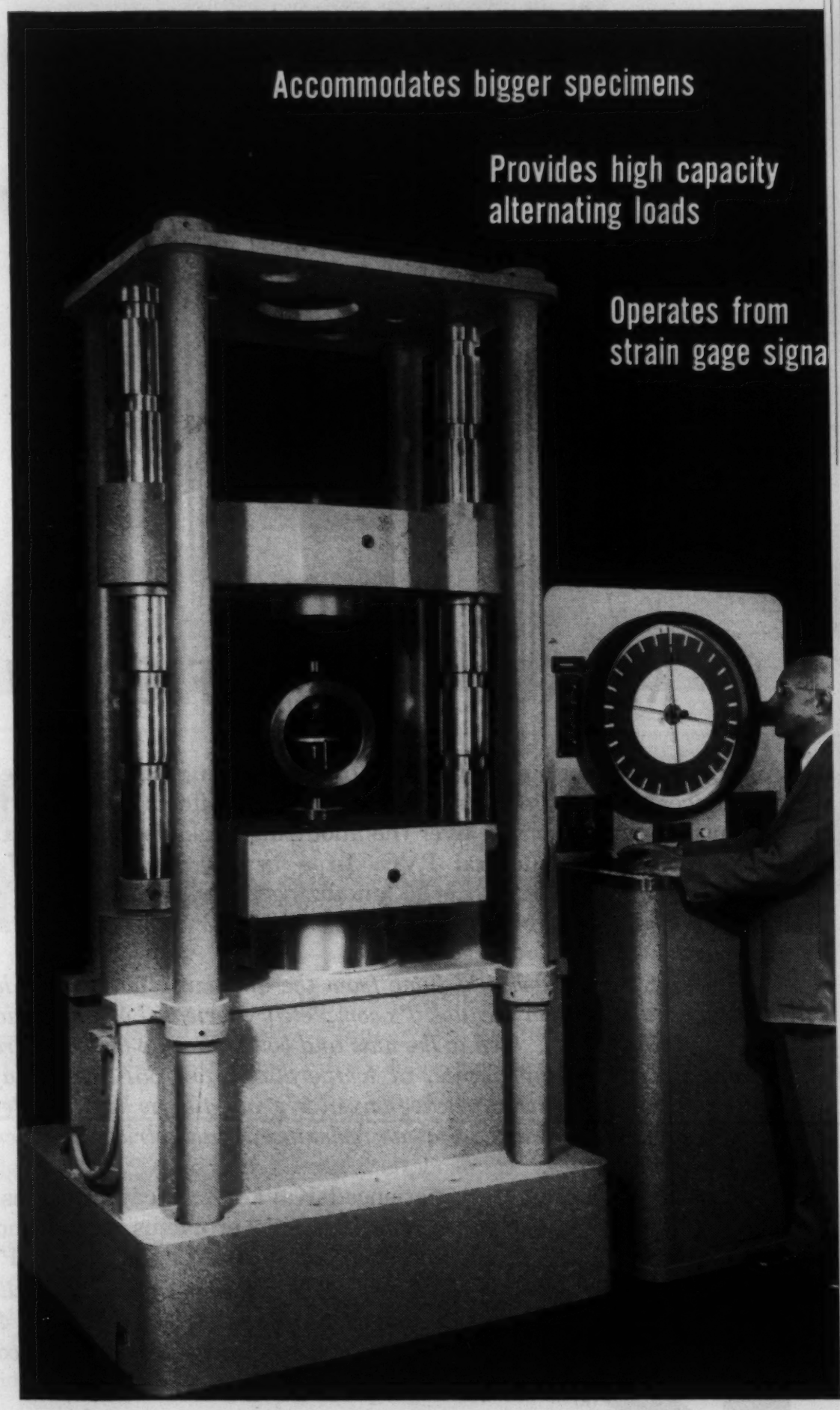
Richard E. Tisch, formerly associated with Pacific Div., Bendix Aviation Corp., has been named manager of the new product development engi-

new 150,000 lb. capacity Baldwin SR-4® universal

From "Testing Headquarters" comes this new Model FGT 150,000 lb. universal testing machine with all these advantages for *you:*

- Full 30″ clearance between columns, plus greater height to accommodate bigger specimens.
- Machine has greater rigidity (due to stay plates at top) and is more resistant to lateral forces (it's a screw within a piston running in a cylinder which supports it in every direction).
- Equipped with ball bearing screw.
- Provides load cycling without changing position of specimen.
- SR-4 indicating unit has practically instantaneous response.
- Can be operated from strain gage signals to reproduce service conditions in the laboratory. Signals from actual field tests are stored on magnetic tape to control this testing machine automatically.

Loads are measured by Baldwin SR-4 transducers, and output may be fed to printers, converters, typewriters and card punch systems. For full information write Dept. 2123, Electronics & Instrumentation Division, BLH Corporation, Waltham, Massachusetts.



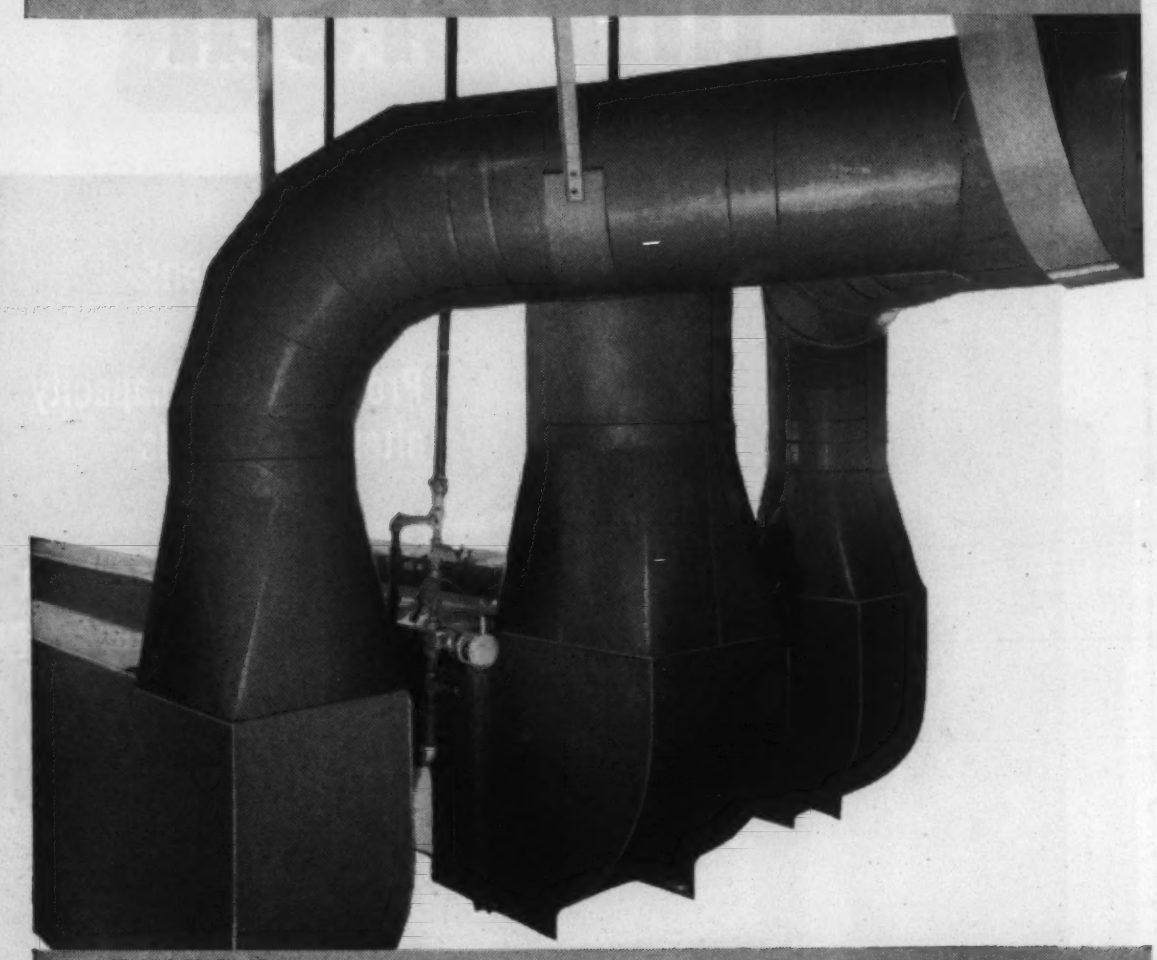
For more information, Circle No. 557

BALDWIN · BLH · LIMA-HAMILTON

ELECTRONICS & INSTRUMENTATION DIVISION
BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Hamilton • Lima • Electronics & Instrumentation • Madsen • Loewy-Hydropress • Pelton • Standard Steel Works

anodizing fume corrosion stopped



by KAYKOR VYFLEX® F-92 PVC

A large midwestern manufacturer of aluminum parts for household appliances was having corrosion troubles. All efforts to keep a fume exhaust system in service over the anodizing tanks failed . . . until he discovered F-92 structural PVC. In a typical application of this tough, resistant material, his 25′ anodizing tanks were equipped with F-92 hoods, which vented fumes to 24″ and 32″ stacks of the same material.

Sulfuric acid splash and fume from the anodizing tanks can't harm the new exhaust system because it's completely fabricated of unplasticized Polyvinyl Chloride . . . even to the nuts and bolts. Inert to the widest range of corrosive processing agents, at temperatures to 165F, this Kaykor material also offers such attractive physical properties as high tensile and flexural strength, hardness, abrasion resistance, and electrical and thermal insulation properties.

Well equipped, highly experienced Kaykor fabricators across the country stand ready to solve *your* corrosion problems with standard or custom designed equipment and parts of VYFLEX F-92 PVC.

GET THE FACTS! Write for complete information in new Bulletin "F-92", available free on request to Kaykor Industries, Inc., 4405 Broad St., Yardville, New Jersey, or ask your local Kaykor fabricator.

KAYKOR INDUSTRIES INC.
Division of Kaye-Tex Manufacturing Corp.
YARDVILLE, NEW JERSEY

For more information, turn to Reader Service Card, Circle No. 543

news of ENGINEERS

neering department, Minnesota Rubber & Gasket Co.

Arthur L. Goeschel has been named manager of the Santa Rosa plant of NRC Metals Corp.

Fred N. Singdale has joined Nevada Testing Laboratories, Ltd., as vice president and general manager.

Dr. Samuel Korman of the Research Dept., Phelps Dodge Corp., is an adjunct professor in the Metallurgical Div., Dept. of Mechanical Engineering, Polytechnic Institute of Brooklyn.

G. E. Hutchinson has assumed the newly created position of manager of quality control, Rem-Cru Titanium, Inc.

Elmore H. Broadhurst, former works manager of the Titusville, Pa., plant of Universal-Cyclops Steel Corp., has been named general manager—Cyclops Div.

Don Blackmar is chief metallurgist in charge of the newly established Le Roi Div. metallurgical and chemical laboratory, Westinghouse Air Brake Co.

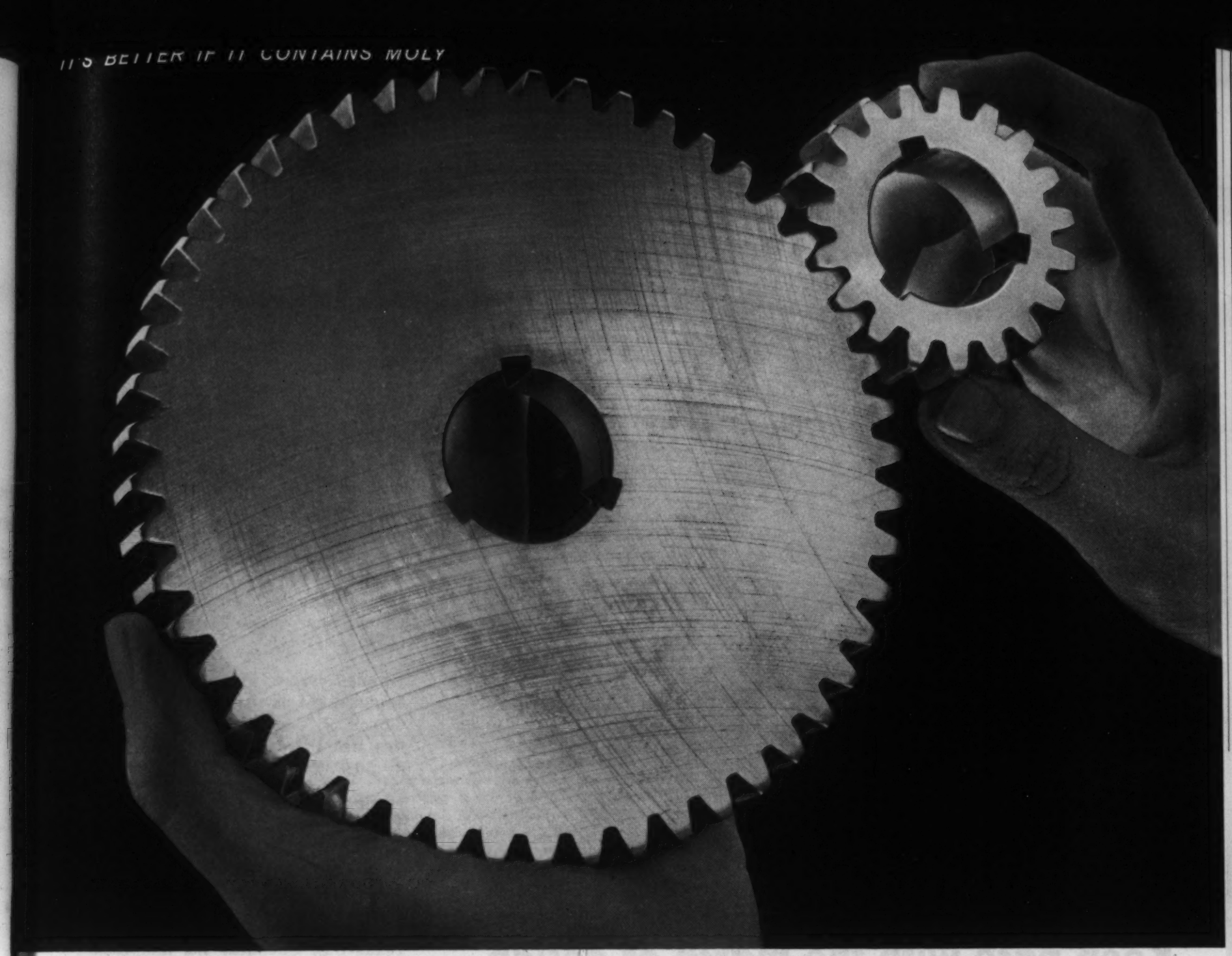
Stanley R. Cope, president of Acme School of Die Design Engineering, recently was presented the 1956 Presteel Award, which is sponsored by Worcester Pressed Steel Co. in association with Pressed Metal Institute.

Dr. F. Leroy Foster, formerly director of the Division of Industrial Cooperation, Massachusetts Institute of Technology, has been appointed director of the Institute's newly established Division of Sponsored Research. **James M. West,** who was an assistant in the Division of Defense Laboratories, is associate director of the new division. **Henry W. Fitzpatrick,** formerly director of the Division of Defense Laboratories, has become assistant director for administration of M.I.T.'s Lincoln Laboratory.

Donald L. McClure, recently appointed general manager of the Corrulux Div., L.O.F. Glass Fibers Co., died suddenly on Sept 14.

William J. Palmer, vice president in charge of manufacturing, Phelps Dodge Copper Products Corp., died Aug 30 at age 66.

(News of Companies on p 234)



Up to 1% Moly in carburizing steels gives required hardenability economically

Why limit the use of molybdenum to the .15/.25% Mo and .20/.30% Mo contents of the traditional grades? For the contributions of moly do not stop there. Laboratory tests and production runs prove that as molybdenum contents increase up to 1%, hardness increases progressively. A wide range of case and core hardenabilities, therefore, can be obtained – economically, too.

Tests with a series of molybdenum-manganese steels show that these compositions give higher case hardness on a direct quench than other steels of comparable core hardenability. One extensively tested composition, for example, is 0.5% Mo – 0.5% Mn steel. It shows longer life, and is lower in cost than steels previously used. And it produces a higher case hardness with similar or less distortion. What's more, tool life and surface finish are equal or better. Good reasons why several companies have already adopted this grade for automotive gears and other critical applications.

If you use carburizing steels, see what a higher molybdenum content can do for you. Part of the story is contained in the technical article "New Carburizing Steels For Critical Gearing." For your copy, or other technical data, write Climax Molybdenum Co., Dept. 6, 500 Fifth Avenue, New York 36, N. Y.

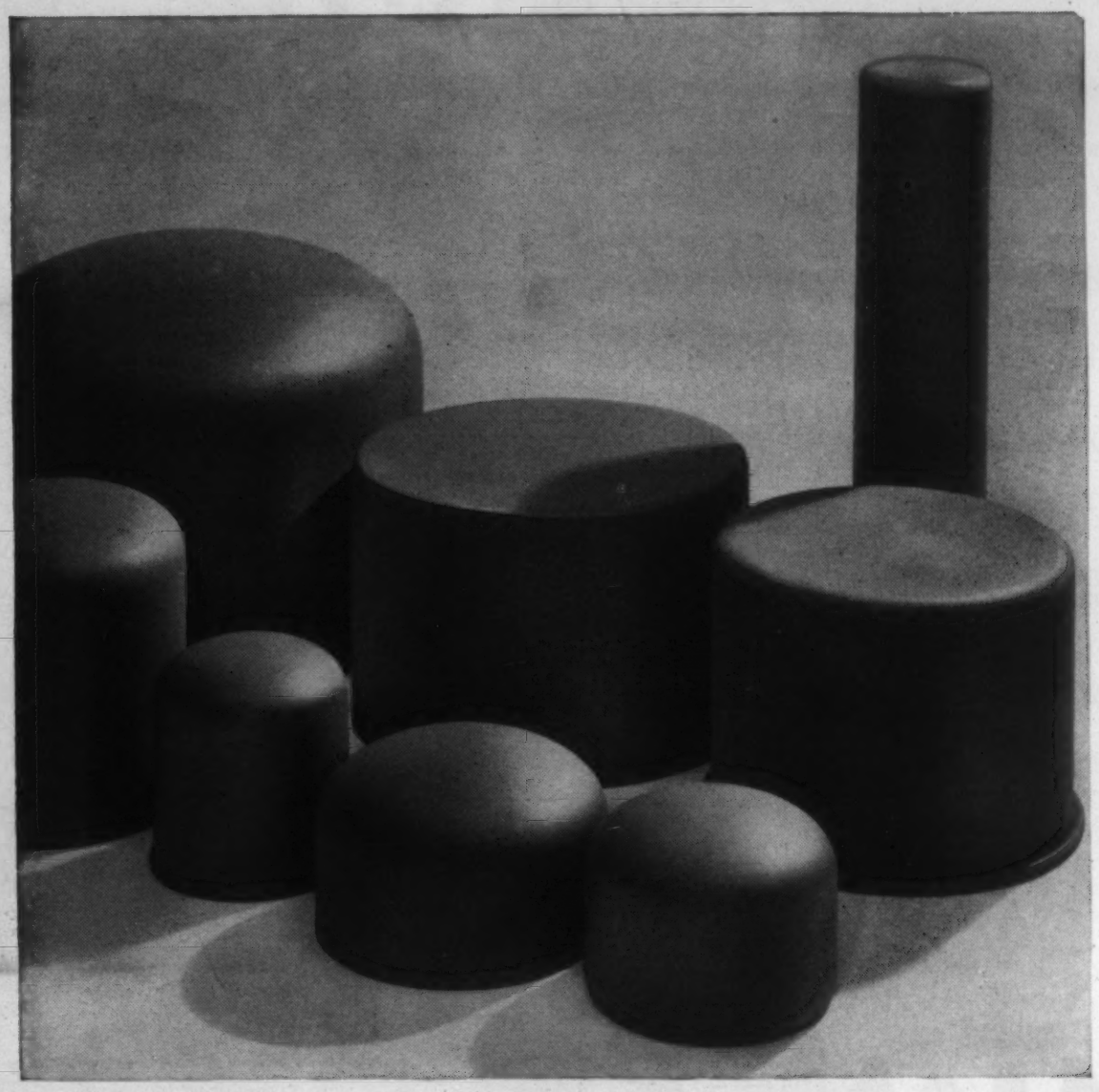
CLIMAX MOLYBDENUM

For more information, turn to Reader Service Card, Circle No. 476

Use the Moly Key to better carburizing steels

CLIMAX MOLYBDENUM

- High case hardness
- Wide choice of hardenability
- Easy to heat treat
- Low distortion
- Good machinability
- Good wear resistance



Keep pace with the march of design with Hackney deep drawn shells

Your customers want smartly designed products...good looking and durable. Your production engineers demand parts that are readily obtainable...easily and quickly assembled...made to accurate specifications. Management says reduce weight and cut unit costs.

Many product designers have found a single way to solve all these problems. They specify Hackney deep drawn shapes or shells. These lightweight, seamless parts may be cylindrical, spherical, conical or tapered...most any streamlined shape your designs call for. Capacities from one quart to 70 gallons. Flanges, openings, fittings or brackets placed where you need them. Just send us a sketch of what you have in mind. Let us know whether you're thinking of steel, stainless steel, nickel, aluminum, magnesium, copper or alloy. We'll send you the details.

Pressed Steel Tank Company

Manufacturer of Hackney Products

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Hackney MILWAUKEE DOWNINGTOWN IRON WORKS

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service Card, Circle No. 401

news of COMPANIES

National Lead Co. and Allegheny Ludlum Steel Corp., parent companies of **Titanium Metals Corp. of America,** have announced a further expansion of titanium metal production capacity at Henderson, Nev. Output of sponge is to be increased 50%, and related melting facilities for production of titanium ingots are to be expanded 80%.

National Science Foundation has awarded a grant of $500,000 to **Massachusetts Institute of Technology** in support of a nuclear research reactor facility. The grant will make it possible for M.I.T. to proceed with the construction of the reactor, for which plans have been underway since 1952.

Owens-Corning Fiberglas Corp. has begun a major expansion of its Anderson, S. C., plant. The new facilities will increase the plant's output by 50%.

Firth Sterling Inc. has acquired the Yonkers research and laboratory facilities of **Schwarzkopf Development Corp.,** formerly American Electro Metal Corp., and will operate them as a division of Firth Sterling.

Texas-U.S. Chemical Co. and **Goodrich-Gulf Chemicals, Inc.,** are participating in a multi-million dollar expansion program that will increase the output of their butadiene plant in Port Neches, Tex., by 50%.

Acme Steel Co. has purchased Newport Steel Corp. Newport will be operated as a new Illinois corporation under the name of **Acme-Newport Steel Co.**

Fansteel Metallurgical Corp. has chosen Muskogee, Okla., as the site of a new $6,500,000 tantalum-columbium plant.

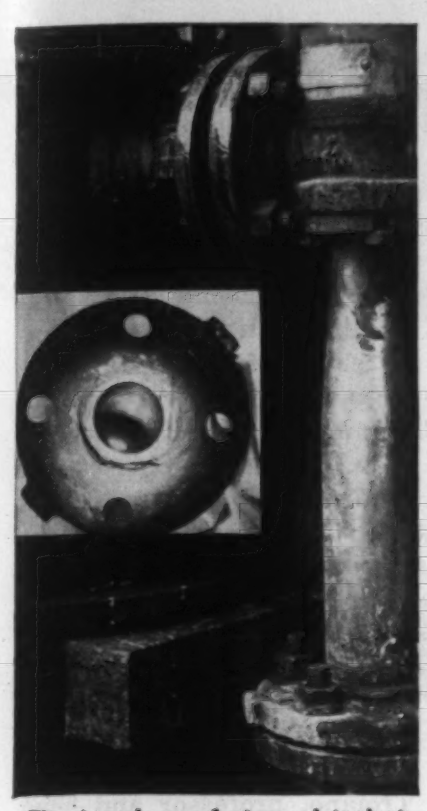
H & H Machine Co., Inc., Norristown, Pa., has been formd to specialize in fabrication of tubular metal products.

Reeves Brothers, Inc. has enlarged its operation in the plastics field by acquiring **Vi-Plax Products Corp.** and **Garrison Co.** Both companies will be merged as a corporate subsidiary of Reeves Brothers, Inc., under the trademark "Viplax."

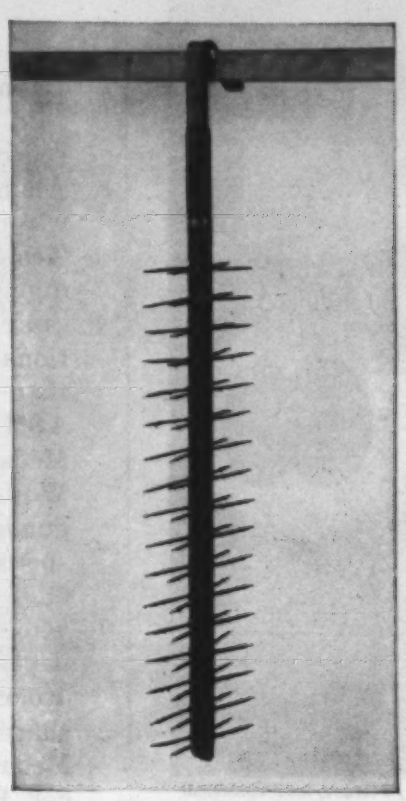
Rimer Precision Casting Co., Waterville, Ohio, has been organized to produce small, intricate parts in ferrous and nonferrous alloys by the investment casting process.

(News of Societies on p 236)

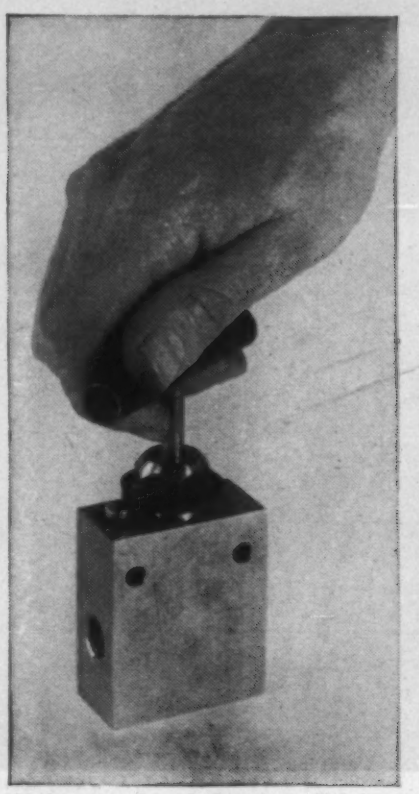
MALLORY·SHARON reports on TITANIUM



Titanium bore of steam jet ejector installed at DuPont shows no corrosion despite exposure to hydrochloric acid and high velocity steam. Previously, bore of different material had to be replaced frequently. Compare titanium bore to cast-iron flange.



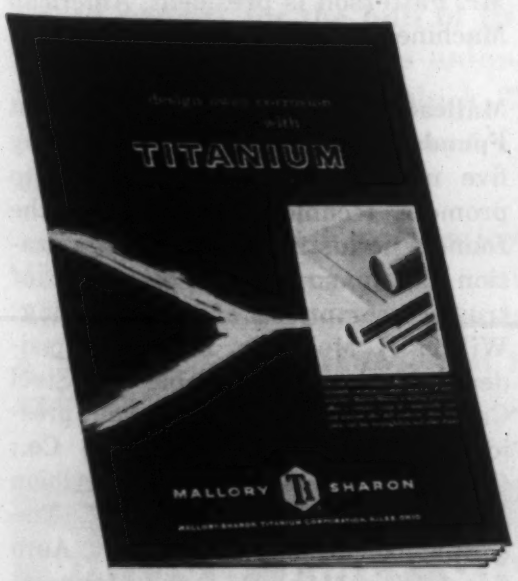
Use of titanium in an anodizing rack has increased useful life from forty-five hours to one year. The sulphuric acid electrolyte used in anodizing operations quickly attacked the material previously used. Made by R. W. Renton Co.



Valve made of titanium for handling corrosive materials. Titanium is now much easier to fabricate than it was even a year ago. Thus piping, tubing, and complicated fittings are now available. Made by Autoclave Engineers, Inc.

Where use of Titanium piping is indicated, it can mean fewer shutdowns, contribute to safer operation. These Ladish Seamless Butt Welding Fittings, by Ladish Co., show versatility in fabrication of variety of fittings . . . elbow, tee, cap, and reducer.

Where **TITANIUM** *stops corrosion*



DESIGN AWAY CORROSION WITH TITANIUM

New booklet lists available data on titanium's corrosion-resistant properties, shows typical applications, and includes corrosion data charts covering behavior with many common acids and industrial chemicals. For free copy write Mallory-Sharon Titanium Corporation, Dept. G-11, Niles, Ohio.

• Titanium offers outstanding resistance to many common corrosive media, including some of the most troublesome industrial chemicals — nitric acid, moist chlorine, chlorinated organic or inorganic compounds, etc. Titanium is not susceptible to stress corrosion, and resists pitting attacks in solutions which affect other metals.

Use of this new metal can end costly shutdowns, replacements, and hazards from corroded parts. Wherever corrosion presents a tough problem, we suggest you investigate titanium. Write and tell us the nature of your corrosion problem—our service engineering group can furnish technical data, and will propose a plan for economical evaluation.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti® SHARON

For more information, turn to Reader Service Card, Circle No. 520

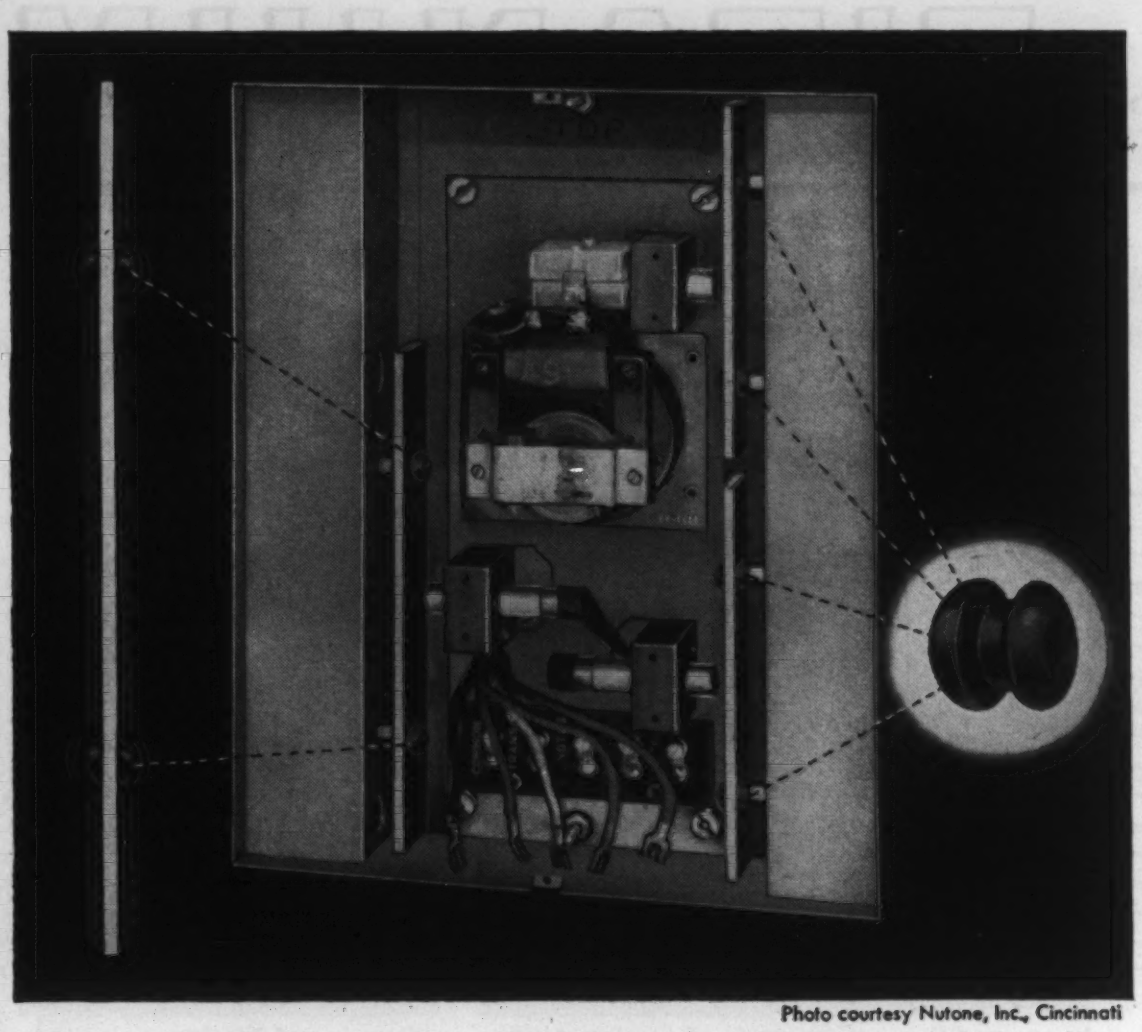


Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**

engineered by **CONTINENTAL**

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For more information, turn to Reader Service Card, Circle No. 515

news of | SOCIETIES

American Society for Metals honored seven leaders in the metals field with awards at the recent National Metal Exposition and Congress. Edgar H. Dix, Jr., assistant director of research at Aluminum Co. of America's Aluminum Research Laboratories, was presented the Albert Sauveur Achievement Award for his outstanding work in aluminum alloys research. William H. Eisenman, national secretary of ASM for more than 39 years, was chosen for the ASM Gold Medal. ASM's Research Medal was given to Charles M. White, chairman of the board, Republic Steel Corp., for his consistent sponsorship of metallurgical research and development. Three scientists, who jointly authored a technical paper on "Delayed Failure and Hydrogen Embrittlement in Steel," shared the Henry Marion Howe Medal Award; they are Dr. Alexander R. Troiano, professor and head of Dept. of Metallurgy, Case Institute of Technology; Dr. William J. Barnett, of General Electric Co.; and Dr. Richard P. Frohmberg, senior engineer with North American Aviation Corp. Dr. Ernest P. Nippes, professor of metallurgy, Rensselaer Polytechnic Institute, was presented ASM's Teaching Award for his outstanding performance in teaching of technical men.

American Standards Assn. has elected Morehead Patterson as chairman of the Nuclear Standards Board. Mr. Patterson is president, American Machine and Foundry Co.

Malleable Research & Development Foundation has been incorporated by five malleable casting foundries to promote technical progress in the foundry industry. The new organization is managed by a board of trustees comprised of the following: Wilson H. Moriarty, first vice president, National Malleable & Steel Castings Co.; Anthony Haswell, president, Dayton Malleable Iron Co.; Collins L. Carter, president, Albion Malleable Iron Co.; Waldo V. Tiscornia, executive vice president, Auto Specialties Mfg. Co., and John A. Wagner, president, Wagner Malleable Iron Co. Mr. Moriarty is chairman of the board and Mr. Haswell is vice chairman.

Society of Automotive Engineers has moved its headquarters to new offices at 485 Lexington Ave., New York 17, N. Y.

Rough water or heavy load—the Crosby Hydrodyne Runabout can take it. Built by the Crosby Aeromarine Co., Grabill, Ind.

Cutting through the water... cutting down the cost— with Bigelow Rovcloth*!

BIGELOW
Fiber Glass Products

It cruises along – strong and swift... with a hull that will not rust, warp, stain, or corrode!

But that's not the only reason why the Crosby Aeromarine Company chose Rovcloth #6060-0505 (Bigelow's woven roving) for the hull of its deluxe 16' Hydrodyne Runabout motorboat. This unique wide fiber glass reinforcement—44" wide, .048" thick, 25.5 oz. in weight—boasts breaking strength in excess of 1,000 lbs. in both warp and fill.

With Rovcloth, you enjoy extreme ease of handling, fast hand lay-up time... savings in time and labor. And, because you use less resin with Rovcloth, you obtain a higher glass-resin ratio – that means *dollars* saved on every unit!

*A Bigelow Trademark

A BIGELOW FIBER GLASS PRODUCT FOR EVERY NEED!

Rovcloth is just one of Bigelow's complete line of plastic reinforcing materials designed to do a superior job at lower cost to you. Consult Bigelow's expert engineering staff about any production problem you have. For further information and technical data sheet, fill in this coupon.

Note: Rovcloth woven in widths up to 218"

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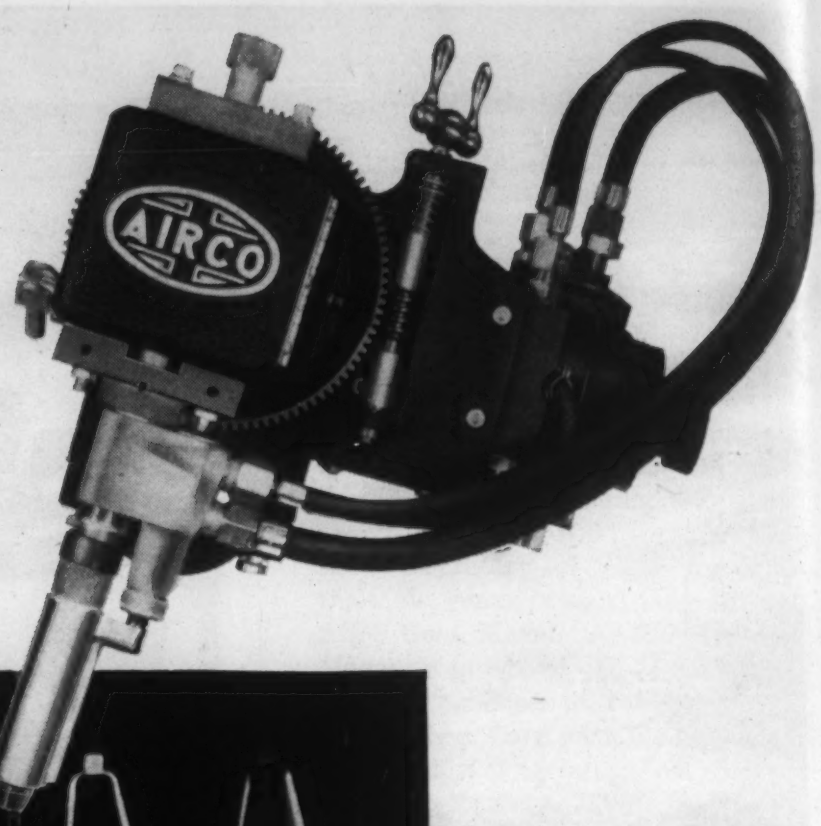
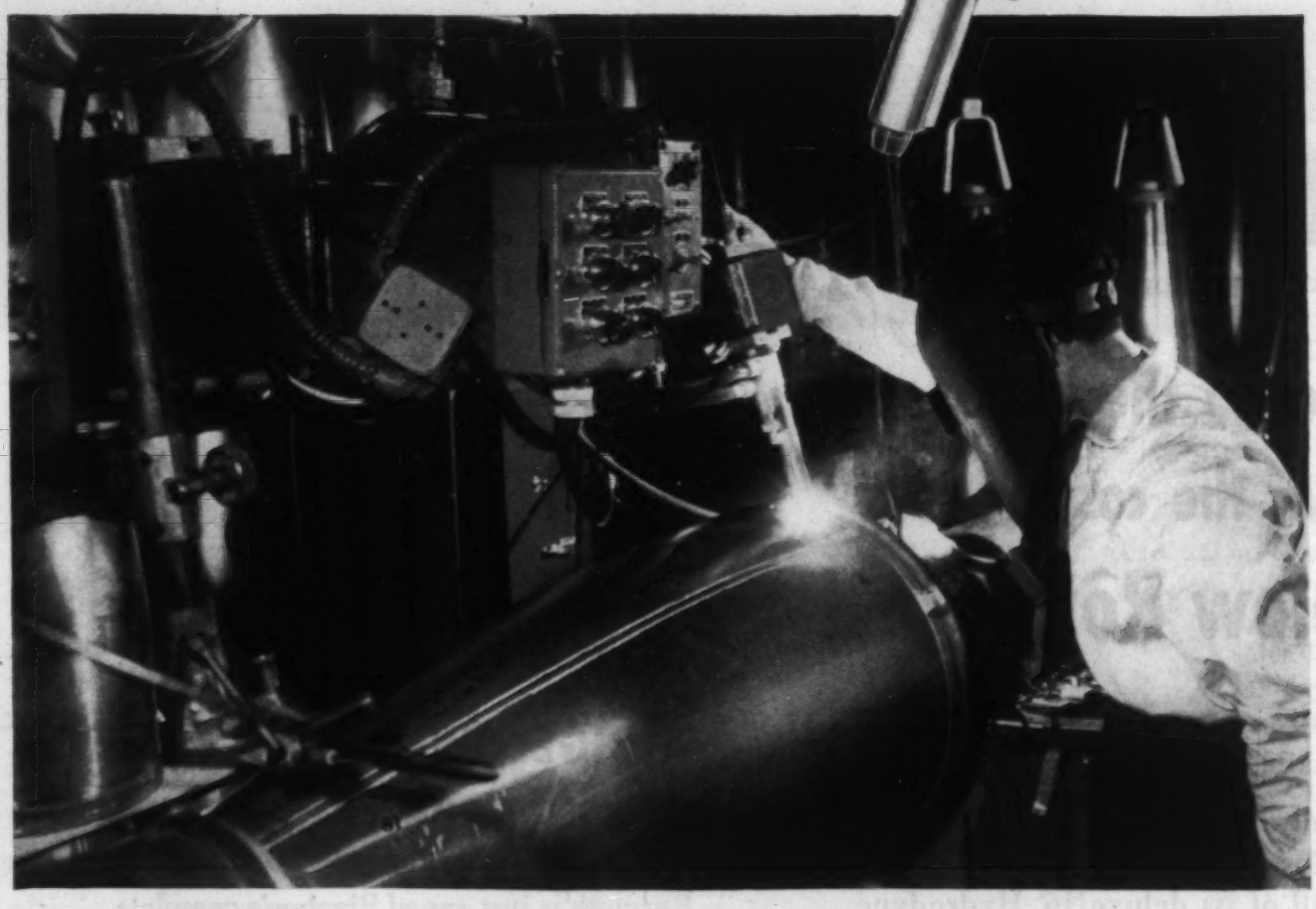
Distributed in Canada by Dominion Rubber Company, Ltd., Textile Division, Kitchener, Ontario.

For more information, turn to Reader Service Card, Circle No. 528

New AIRCOMATIC® HEAD for better machine welding





New AMH-B Head welding cylindrical containers on a high production basis. All components of this Aircomatic package — power supply, inert gases, and Aircomatic welding wire — are available from Airco.

The new improved Airco AMH-B Aircomatic Head has been developed for the fabrication of ferrous and non-ferrous metals on a high production basis. Used in conjunction with constant arc voltage power supply, this unit provides automatic control of the arc voltage. Standard shielding gases—argon, helium, mixtures (AG75) and CO_2 — are used. Advantages of the AMH-B include: two speed ranges, up to 900 inches per minute high range, and up to 600 inches per minute low range; all types of Aircomatic welding wire, from .030" to 3/32" diameters, can be used.

Wire is fed at a constant speed by an adjustable speed motor. Easy adjustment of the head allows it to be used vertically or horizontally.

For handling most applications the basic package consists of the Aircomatic unit, a machine barrel and a wire guide component kit. The basic Aircomatic unit includes the head, main control panel and remote control operator's station. For complete information write Airco direct.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .

AIR REDUCTION PRODUCT

AIRCO®

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
150 East 42nd Street, New York 17, N. Y.

On the west coast — Air Reduction Pacific Company
Internationally — Airco Company International
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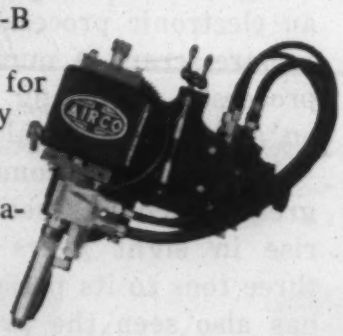
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

For more information, turn to Reader Service Card, Circle No. 535

Note these outstanding advantages of the new AMH-B

- Accommodates wide range of metal thicknesses — take fine wires (.030") for thin gauges, and up to 3/32" for normal gauges.
- Versatility — through availability of 3 machine barrels with duty ratings of 350, 500 and 600 amperes.
- Extreme compactness contributes to ease of installation, setting up, and servicing.
- Designed so that accessory equipment may be connected easily, quickly.
- Easy to mount: only standard 1½" steel pipe is required.
- Can be used with argon, helium, mixtures (AG 75) and CO_2 gases.
- Simplified design means easier maintenance and longer life.

You'll find the new AMH-B Aircomatic Head ideal for high quality welding on production type applications. For complete details



WRITE DIRECT TO

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Meetings and Expositions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. New York, Nov 25-30.

AMERICAN ROCKET SOCIETY, annual meeting. New York. Nov. 26-29.

NATIONAL CHEMICAL EXPOSITION. Cleveland. Nov 27-30.

SOCIETY OF THE PLASTICS INDUSTRY, Film, Sheeting and Coated Fabrics Div. conference. New York. Dec 4-5.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, electric furnace steel conference. Chicago. Dec 5-7.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting and engineering display. Detroit. Jan 14-18.

SOCIETY OF PLASTICS ENGINEERS, annual national technical conference. St. Louis. Jan 16-18.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, Engineers Joint Council. New York. Jan 17-18.

MALLEABLE FOUNDERS' SOCIETY, semiannual meeting. Cleveland. Jan 18.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York. Jan 21-25.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Philadelphia. Feb 4-8.

GRAY IRON FOUNDERS' SOCIETY, committee week and spring meeting. Philadelphia. Feb 4-8.

SOCIETY OF THE PLASTICS INDUSTRY, annual Reinforced Plastics Div. conference. Chicago. Feb 5-7.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, annual meeting. New Orleans. Feb 24-28.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar 5-7.

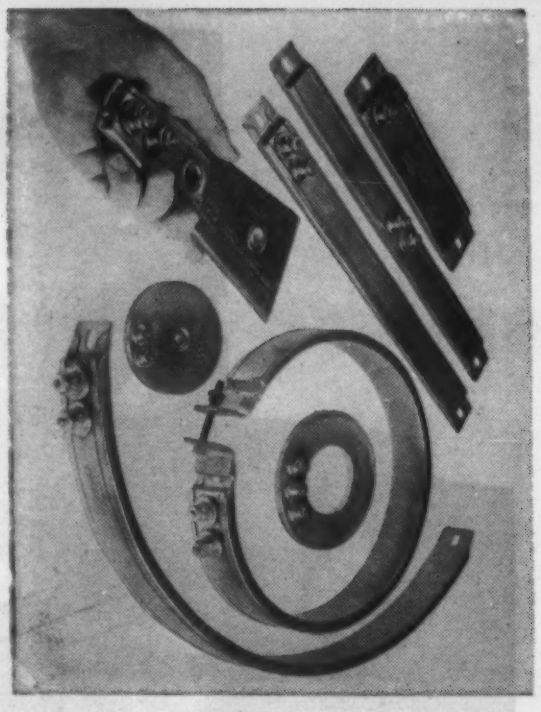
NUCLEAR CONGRESS. Philadelphia. Mar 11-15.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference and exhibition. St. Louis. Mar 11-15.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 18-19.

SOCIETY OF THE PLASTICS INDUSTRY, annual national conference and Pacific Coast plastics exposition. Los Angeles. Mar 18-21.

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting and forum. Buffalo, N. Y. Mar 20-22.



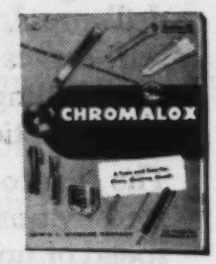
New manufacturing process improves performance of CHROMALOX Electric Strip Heaters

An improved manufacturing process, combined with a newly developed refractory material, offers you the finest performance in strip heaters. Rugged and long lasting, they are industry's workhorse among heating elements.

So when you use the improved line of Chromalox Electric Strip Heaters, you're assured of even better performance in the heating of platens, dies, kettles, tanks, ovens, air ducts and other applications that require dependable, accurately controlled heat . . . where and when heat is needed.

Let the Chromalox Sales-Engineering staff solve your heating problems—electrically.

Write for your copy of Catalog 50



This data-packed catalog covers the design, uses and prices of the complete line of Chromalox Electric heaters, elements, thermostats, contactors and switches.

To get short factual material on many additional applications of electric heat, send for Booklet F1550 "101 Ways to Apply Electric Heat."

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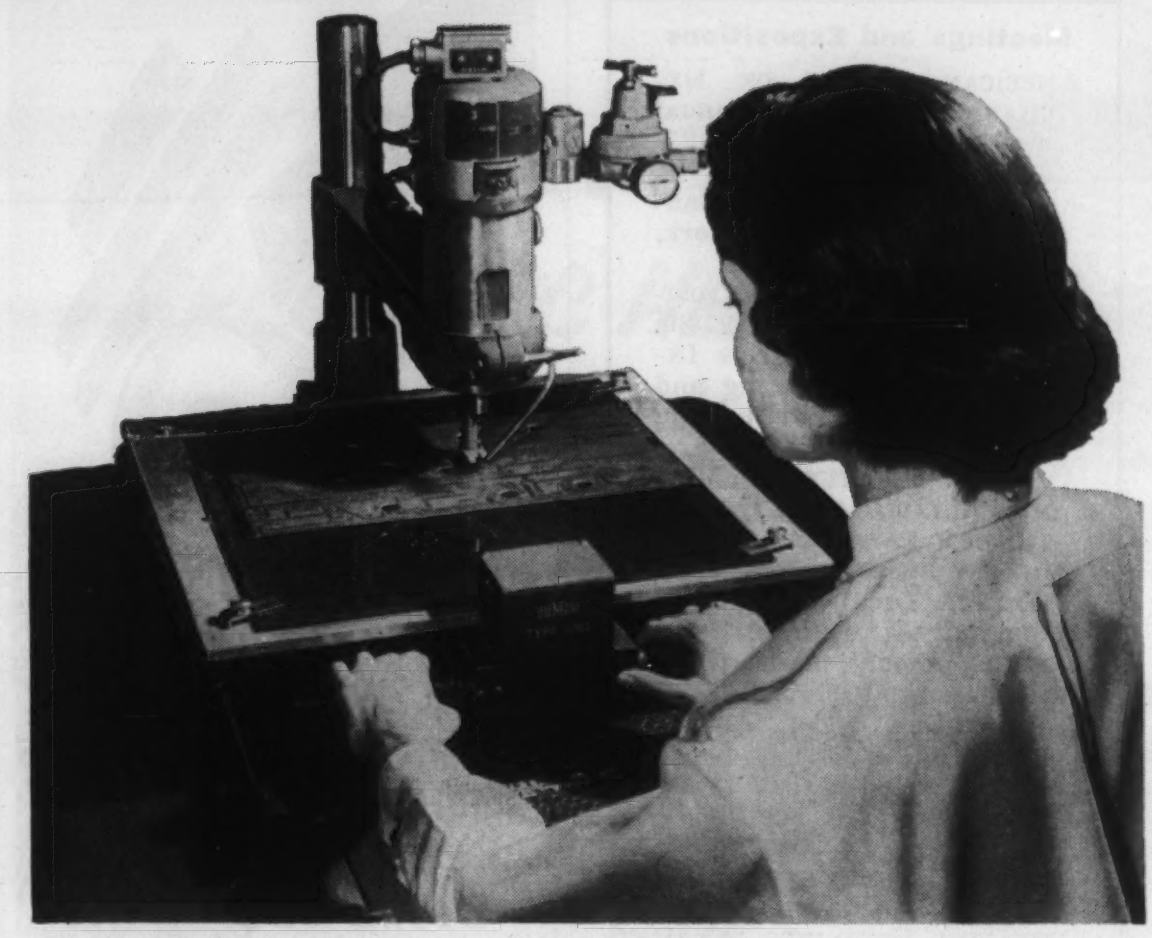
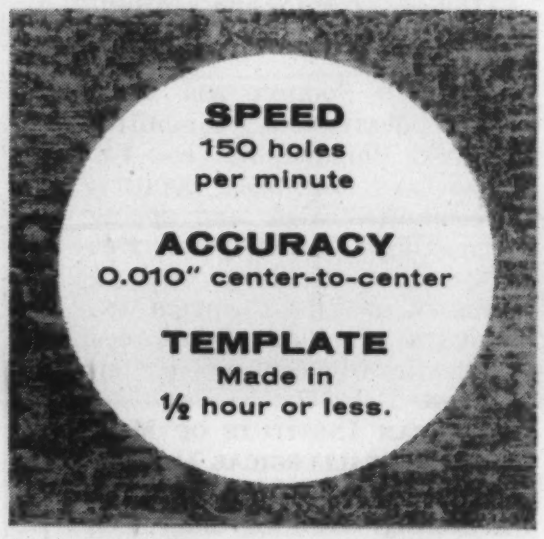


PANTODRILL CUTS COSTS

The answer to semi-high-speed production board drilling —at lowest possible cost . . .



The Du Mont Pantodrill requires no expensive tool or jig making. A simple template, made on a drill press, or the Pantodrill itself, serves as a guide to accurate drilling of up to thousands of production pieces.

The Pantodrill may be operated by unskilled personnel at a speed of up to 150 holes per minute with an accuracy of 0.010" center-to-center. The Pantodrill operates on a simple, foolproof principle which completely eliminates rejects due to misdrilling.

A pressure sensitive feed on the drill head automatically adjusts feed rate for all types of materials. Boards may be stacked up to 1" thickness so that a quantity may be drilled simultaneously.

The Pantodrill is the answer to economical pilot runs, or limited production runs.

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ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, NEW JERSEY

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MATERIALS ENGINEERING NEWS

TITANIUM . . . *cont'd from p 11*

years will be the application of the permutations and combinations of the basic heat treatment procedures to alloys of the type we now have, or modifications of them. The advances will be in terms of realizing in commercial handling the full heat treat potential that now exists and, through alloy and heat treatment, to obtain better compounds of properties for a given job."

Supply and demand

Speakers at the symposium gave assurance that demand is improving, that the supply of primary metal sponge is more than adequate for our present needs and that its quality has been steadily improved during the last two years.

"The increased demand is very important," said Francis C. Frary of the National Research Council, "since practical experience is the only means by which the fabricators can solve their production problems." With four large producers and several companies with smaller pilot plants, ample competition is developing the technology of producing the metal by reduction of the tetrachloride with either magnesium or sodium. In addition, two other companies have promising electronic production processes operating in small pilot plants, and the Bureau of Mines has developed and described an electronic process for refining impure scrap. A number of other processes are being investigated on a laboratory scale.

Much of the commercial progress which has seen production rise in eight years from about three tons to its present level and has also seen the primary metal price reduced by 40¢ in three years, has been made possible by Government financial aid, particularly in guaranteeing a market.

Other points discussed at the symposium include:

1. The production of shaped castings is still highly experimen-

Researchers:

Lithium Corporation INVITES YOU TO EXPLORE THE POSSIBILITIES OF LITHIUM COMPOUNDS AS POLYMERIZATION CATALYSTS

Lithium metal, lithium hydride, lithium hydroxide and lithium carbonate are the basis for both experimental and commercial studies as polymerization catalysts in the manufacture of certain plastics, polymers and resins. The polymerization reactions may be "addition" or "condensation" processes.

This new research tool has tremendous potential. The use of lithium metal as a catalyst for the polymerization of diolefins has been known for many years. By contrast, lithium metal dispersions were only recently used to polymerize isoprene to a "natural" rubber.

Lithium carbonate, to cite another example, is a preferred catalyst for the esterification of tall oils. Again, lithium hydroxide has been found to be a superior catalyst for the manufacture of alkyd resins. And work has been done with lithium hydride for ester interchange reactions.

In case you have a catalyst problem in mind requiring the use of highly reactive lithium, our PR&D department is making available information on this new and highly valuable research tool. Describe your application or request general information.

. . . trends ahead in industrial applications for lithium

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This high performance, economical static seal may save you money and grief over the type you are now using . . . in static, and in some cases moving applications. TETRASEAL rectangular-section rings by Goshen are non-laminated (in one homogeneous piece). Edges are accurately formed, and cross-sectional tolerances can be held to ± .004 depending on inside and outside diameter, on size of cross-section and on material desired. Now available in materials to meet MIL, AMS and commercial specifications. To find out what TETRASEAL can do for you, write for Technical Bulletin No. 11.

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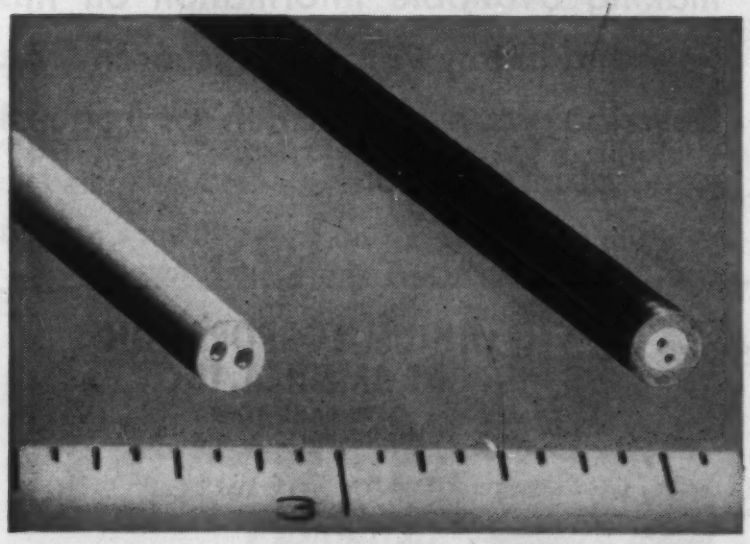

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MATERIALS ENGINEERING NEWS

tal and very expensive.

2. The key to large-scale application of titanium powder metallurgy is contained primarily in the economic considerations. (The development of sintered aluminum products has created much interest in the field of dispersion hardening for improved high temperature performance.)

3. The production of extruded shapes is at present very expensive as compared with the production of sheet for forgings.

4. Details of methods of joining must be studied and effects on efficiency determined.

5. The effects on various properties produced by cold forming (or possible hot forming operations) must be determined.

All of this information is needed not only for commercially pure titanium but also for each alloy that may go into commercial production and use.

RESEARCH . . . *cont'd from p 13*

opment are: lighting by electroluminescence using phosphors placed between two conducting plates; circuit breakers (now in use) in which sulfur hexafluoride is fed in to quench the arc, thereby providing longer life for contact materials; and use of a selenium layer to provide current gain in TV camera pick-up tubes.

National Carbon developments

1. Attainment of a graphite weld. The problem has been that at normal pressures graphite vaporizes when heated to high temperatures. Now pieces of graphite to be joined are placed in an atmosphere of inert argon under high pressure. A direct current passes through the pieces in contact and subsequent separation creates an arc that heats the graphite to high temperatures.

2. Intermetallic compounds. These materials are still in the development stage, the two most advanced being indium-antimony

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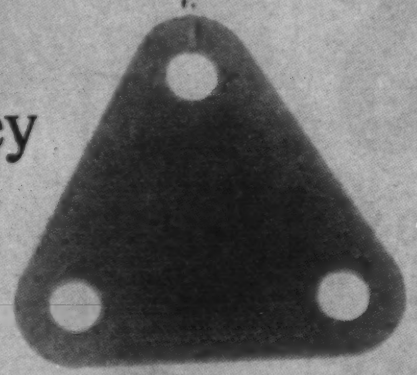

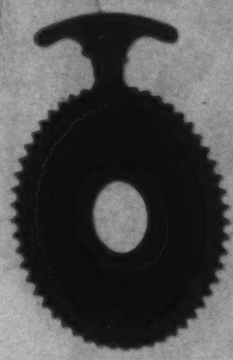

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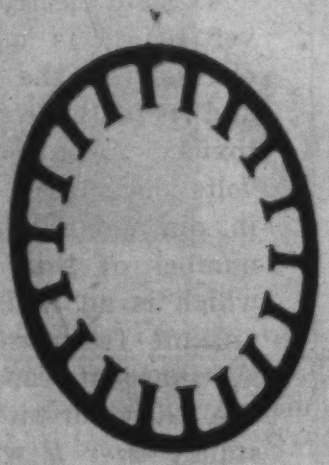

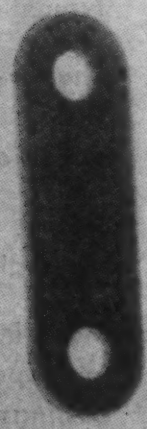

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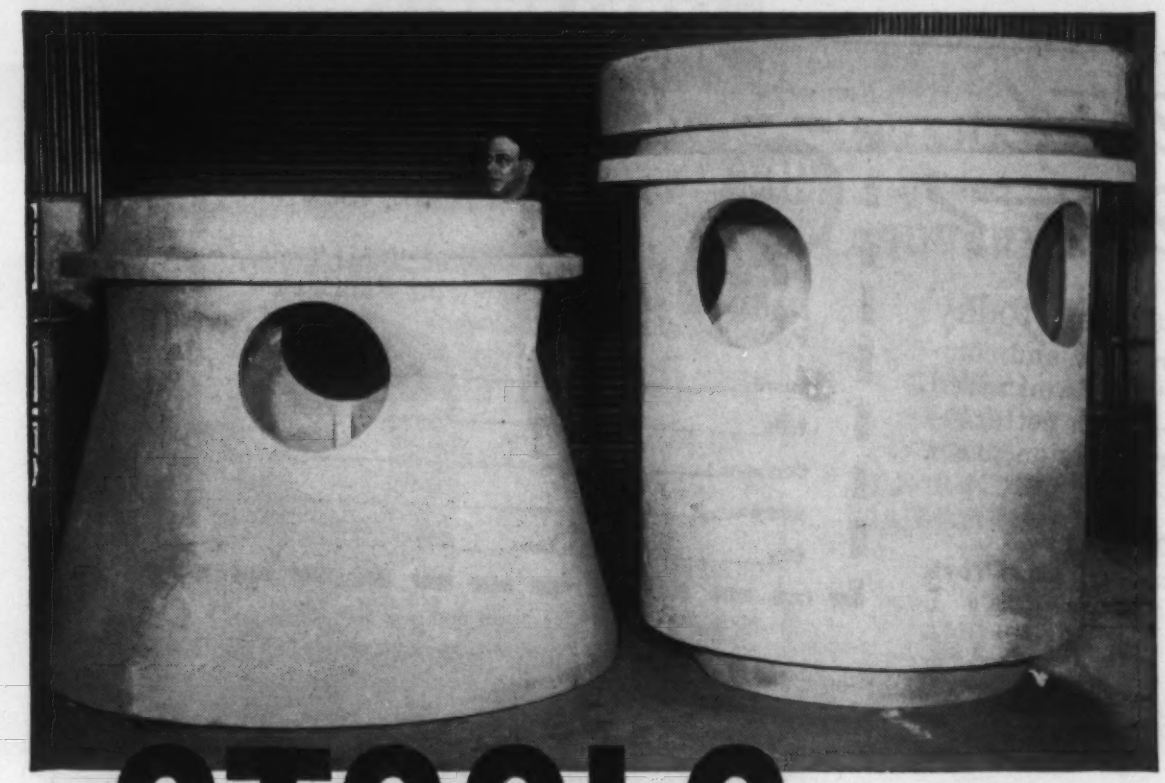

STOOLS

- weighing 10,000 pounds each
- alloyed 25% Cr—12% Ni
- for 1750°F. temperatures

DURALOY

These stools should offer a very pertinent tie-in with your casting requirements. Essentially, they are alloyed to resist heat. They're typical of the heavy high alloy castings we are equipped to turn out.

They will serve also to indicate what we can do in the way of producing castings to resist not only high temperatures but severe corrosion or combinations of heat and corrosion, as well.

Today, we can offer several distinctly different types of castings in the high alloy field including static, centrifugal and shell-molded.

Many in both the metal working and processing fields have come to look upon Duraloy as the leading producer of exclusively high alloy castings. This reputation has been built on many years production of sound castings properly alloyed. We'll be glad to discuss your high alloy casting requirements.

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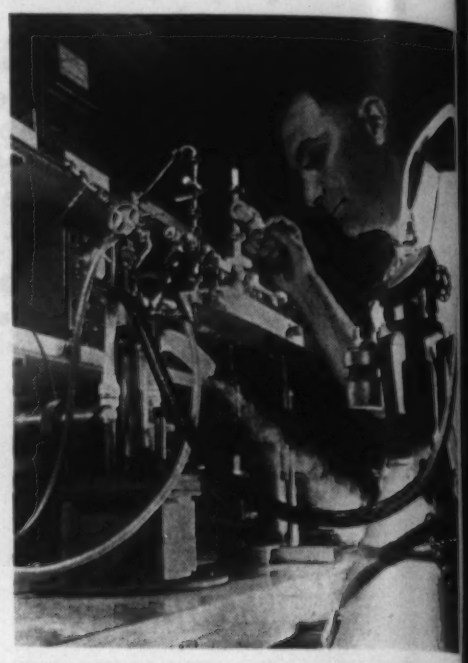
MATERIALS ENGINEERING NEWS



Fundamental research—*Westinghouse physicist uses microwaves to study superconductivity of metals at temperatures less than one degree above absolute zero.*

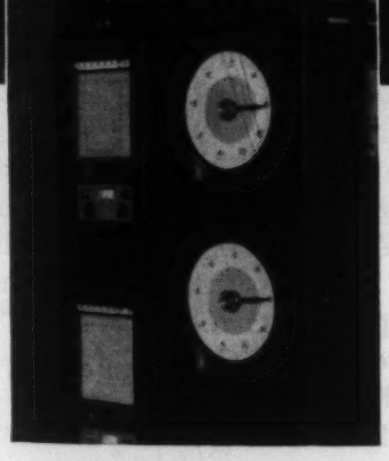
and magnesium-tin. These are metallic compounds made of two different metals without any bonding phase.

3. High temperature refractory materials. Under particular study are titanium diboride and cerium monosulfide, expected to be serviceable up to 3600 F.

4. Solid electrolyte battery. Silver iodide is used as the solid electrolyte; the anode is silver and the cathode is vanadium pentoxide. A battery delivering 90 volts measures about 1 in. x ½ in. dia and is built up of a large number of thin wafers, each of which is an individual cell. Significant features are said to be its inherent capability for long life (20 yr or more), voltage constancy over a wide temperature range, and adaptability to miniaturization.

5. Other projects include: a fuel cell comprising two carbon tubes mounted in a closed container filled with a fluid electrolyte; high altitude (60,000 ft) brush testing; field emission microscopy; and measurement of color and light of carbon arc lamps.

The National Carbon plant in



AT ATHENIA STEEL

Speedomax® H eliminates M.T.C.*

At the Athenia Steel Division of National-Standard Company—flat spring steel specialists—Speedomax H controllers are helping operators meet customer specs on cold rolled flat wire. Since installing these new instruments, production has increased . . . down-time reduced . . . and Athenia Steel is assured of the proper temperature for each charge.

In line with its modernization program, Athenia has already completed installation of Speedomax H control on two continuous gas-fired hardening and tempering lines. Former method of control required manual adjustment of valves to regulate gas input to the furnaces. But with Speedomax H, fuel input is now controlled automatically. Two Two-Position Indicating Controllers are holding temperature of the first two zones of the hardening furnace to better than ±5 F, and a 3-Action P.A.T. Controller holds the finish zone to ±2 F. A second 3-Action P.A.T. Speedomax H controller holds the tempering furnace to ±2 F.

Perhaps Speedomax H can help solve your temperature problems. For further information, contact your nearest L&N sales office or write 4925 Stenton Avenue, Philadelphia 44, Pa.

* *Manual Temperature Control*

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Instruments — Automatic Controls • Furnaces

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Are hand-operated metal cleaning operations the bottleneck in your production flow? Are you putting up with the cost and confusion of centralized cleaning operations? Detrex can quickly solve both of these profit-eating conditions by placing your metal cleaning operation in sequence right within your present production lines . . . automated or otherwise.

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To keep your metal cleaning processes in step with the rest of your production, why not have a talk with your nearest Detrex field technician? Use the coupon below to get the ball rolling today . . . no obligation.

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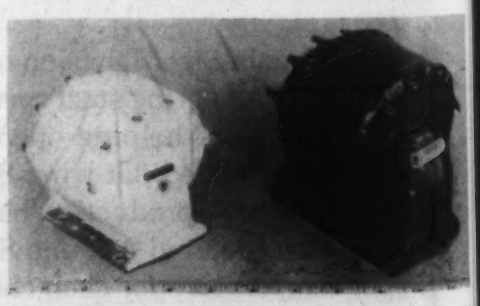
MATERIALS ENGINEERING NEWS

Parma brings to seven the number of major research centers operated by Union Carbide and Carbon Corp. The new laboratory contains 175,000 sq ft, including a main building consisting of 158 laboratory modules equipped not only with the usual service lines but also with lines which distribute various rare gases. Adjacent wings house furnace areas, machine shops, business offices and various personnel service rooms.

The entire laboratory will be under the direction of Dr. Robt. G. Breckenridge, at one time connected with the National Bureau of Standards and the Office of Naval Research. The principal aim of the new research center is to improve existing materials and to discover methods of creating new materials for the metal, electronic, power, chemical and electrochemical industries.

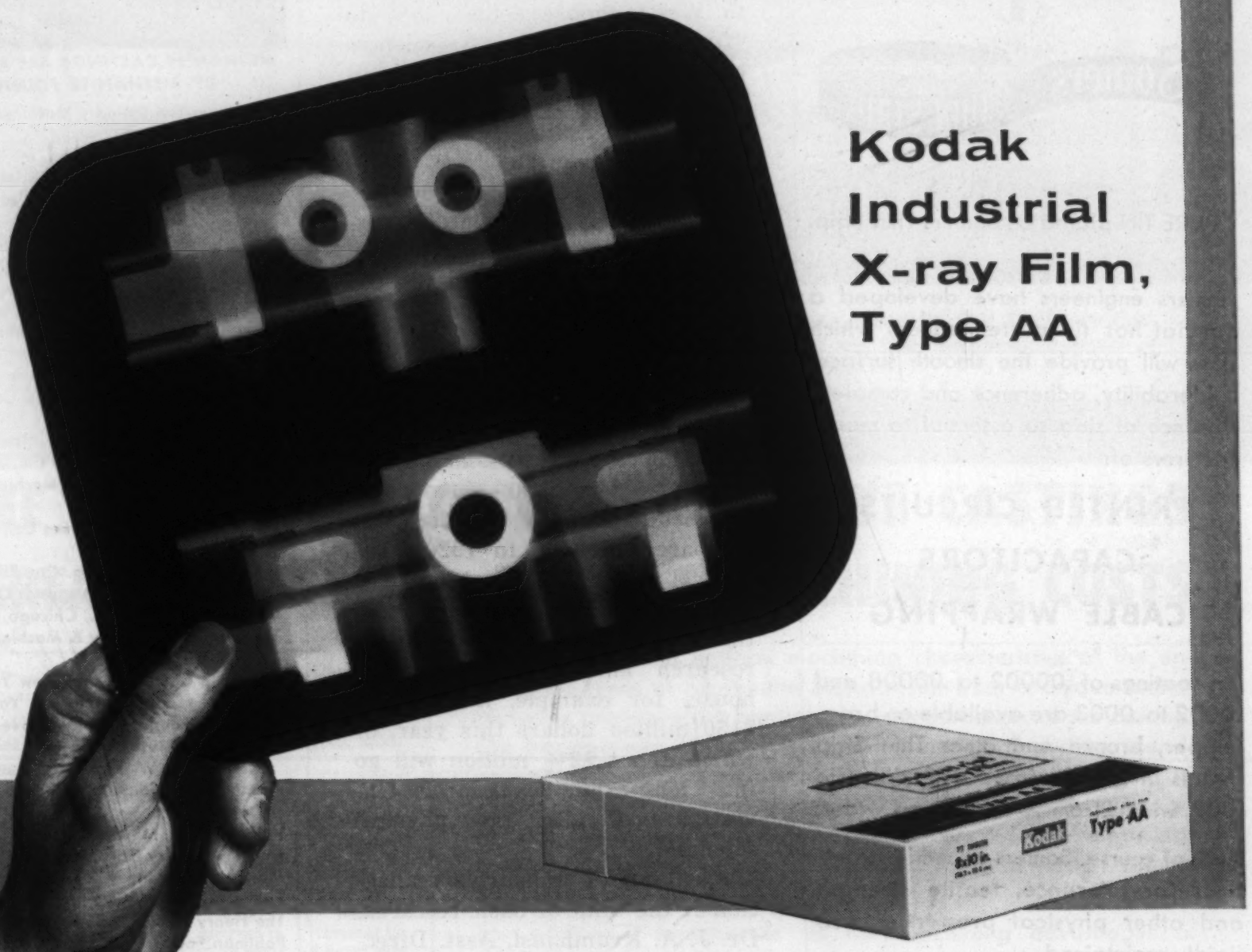
Westinghouse has provided the electrical manufacturing industry with its most modern research facility. The three-story L-shaped building contains more than seven acres of floor area and houses the laboratories, offices, shops and other requirements for a staff of over 7000 people. A modular system of construction for labs and offices permits reassignment of space as changing research requirements dictate. Only 10% of total effort will be toward applied research—work of a prac-



Heat resistant insulation *(using solventless silicone resin) was developed jointly by Westinghouse and Dow Corning. Most important advantage is that part and wire sizes can be reduced to a point which formerly generated too much heat. Aircraft transformer above has been cut down from 8 lb 14 oz to 4 lb 8 oz for same rating.*

New X-ray Film

gives greater detail with usual exposure times



Kodak Industrial X-ray Film, Type AA

Read what the new Kodak Industrial X-ray Film, Type AA, will do for you.

- Reduces exposure time—speeds up routine examinations.
- Provides increased radiographic sensitivity through higher densities with established exposure and processing technics.
- Gives greater subject contrast, more detail and easier readability when established exposure times are used with reduced kilovoltage.
- Shortens processing cycle with existing exposure technics.
- Reduces the possibility of pressure desensitization under shop conditions of use.

Now your x-ray dealer can supply you with this new x-ray film that gives you greatly increased speed. This gives you the opportunity of using reduced kilovoltage to obtain greater radiographic contrast, and easier readability with established exposure times.

And in addition to ranging up to more than double the speed, this new film retains the fine sensitivity characteristics which have made Kodak Type A the most widely used x-ray film in industry.

Kodak Industrial X-ray Film, Type AA, will save you time. It can produce finer work. Get in touch with your x-ray dealer or Kodak Technical Representative and see how.

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Kodak
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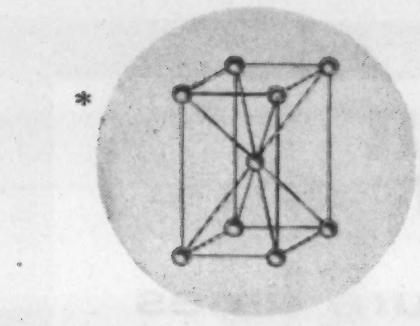

*PURE TIN plated on Somers Thin Strip.

Somers engineers have developed a special hot tin plate process which now will provide the smooth surface, solderability, adherence and complete absence of slag so essential to manufacturers of:

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Tin coatings of .00002 to .00008 and .0002 to .0003 are available on brass, copper, bronze and other Thin Strip metals in gauges from .012 down to .002, widths from ⅛" to 6" and wider.

And, of course, Somers exacting standards for tolerance, tensile strength and other physical properties are rigidly maintained.

Whatever your requirements for tin plated thin strip, you can depend on Somers long experience and modern equipment for a quality product.

Write for further information and confidential data blank. Somers will gladly analyze your problem without obligation.

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MATERIALS ENGINEERING NEWS

tical nature focused on a single product. Fully 50% will be devoted to "basic" research—search for knowledge directly related to Westinghouse fields; 40% to "fundamental" research—sciences basic to the electrical industry but involving projects with little relation to immediate business needs.

Industrial research

These two plants bear out the fact that today a considerable portion of industrial research money is being spent on research variously called pure, basic, theoretical or fundamental. This country is now spending over $5 billion on such research, more than 20 times the amount in the 1920's. At least 200,000 professional scientists and technicians are working full-time on research as compared to 9000 in 1920. The federal government maintains 53 principal laboratories, and more than 4000 business firms maintain research laboratories. Westinghouse, for example, is spending $150 million dollars this year, of which about $2½ million will go into long-range exploratory investigations into the physical sciences.

Speaking of industry's realization of the value of basic research, Dr. J. A. Krumhansl, Asst. Director of the Parma labs, noted that we are still prone to dwell upon the *results* in terms of products, such as transistors, solar batteries, synthetic gems and new rectifiers, but there are many other contributions in the form of improved materials or processes. For example, metals and alloys with improved mechanical properties, improvements in photographic film, advances in powder metallurgy, better phosphors for television, better materials for photoelectricity, materials with improved resistance to nuclear radiation, and improved high temperature materials.

"These are typical of the results of applied research," Dr. Krumhansl stated, "but at the same time I hope I have made it

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DeLaval Steam Turbine Co., Trenton, N. J.
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Hardinge Manufacturing Co., York, Pa.
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Mattison Machine Works, Rockford, Ill.
Palmyra Foundry Co., Inc., Palmyra, N. J.
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Pohlman Foundry Co., Inc., Buffalo, N. Y.
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Sonith Industries, Inc., Indianapolis, Ind.
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Valley Iron Works, Inc., St. Paul, Minn.
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• "HOW TO MACHINE MEEHANITE CASTINGS" BULLETIN NO. 29

MEEHANITE®

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Heavy milling operation on a Meehanite Casting indicates the free machining qualities of Meehanite Metal.

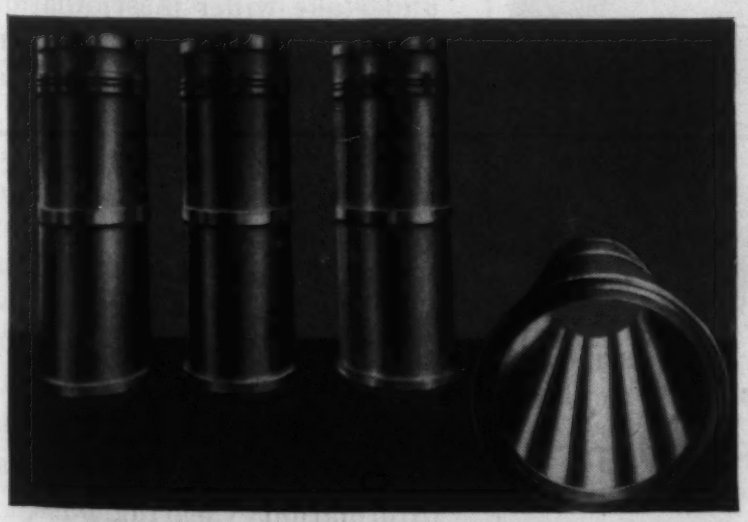
FREE MACHINABILITY OF MEEHANITE CASTINGS INCREASES TOOL LIFE, REDUCES MACHINING COSTS

Machining time to turn, bore, face, key seat, drill, tap and cut on a 3 ft. worm gear. The tabulation below shows savings possible with Meehanite Metal.

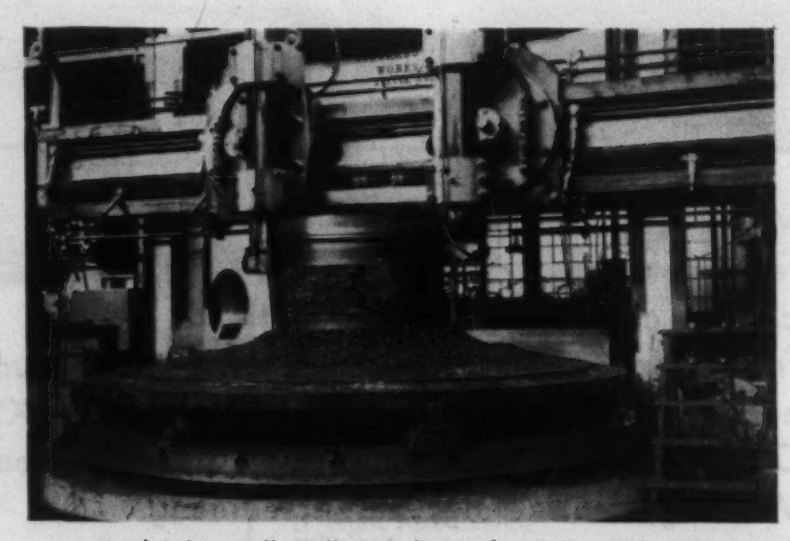
STEEL CASTING 69,000 psi	ALLOY CAST IRON 40,000 psi	MEEHANITE TYPE GB 45,000 psi	MEEHANITE TYPE GB 45,000 psi
183 lbs. metal removed in 20.1 hours.	170 lbs. metal removed in 15.83 hours without coolant.	170 lbs. metal removed in 10.53 hours without coolant.	170 lbs. metal removed in 7 hours with coolant.

The consistent and uniform machining characteristics of the engineering types of Meehanite Metal result from a unique manufacturing process which controls the microstructure of the casting. The homogeneity of structure and uniformity of casting soundness permit higher feeds and faster speeds, thereby reducing to a minimum machining costs as well as casting rejects. Retention of accuracy of casting form and size allows Meehanite castings to be made within definite dimensional limits to further reduce machining costs.

For additional information on the machining advantages of Meehanite, write today for Bulletin No. 29, "How To Machine Meehanite Castings."



Cylinder liner weighing 1100 lbs. were cast in Meehanite type "GB" to give a high machine polish.



Meehanite Ball Mill Head 12 ft. O.D. with 44" diameter trunnion. ¾" deep cut at 140 ft./min. cutting speed removed 37.8 cu. in./minute.

MEEHANITE METAL®

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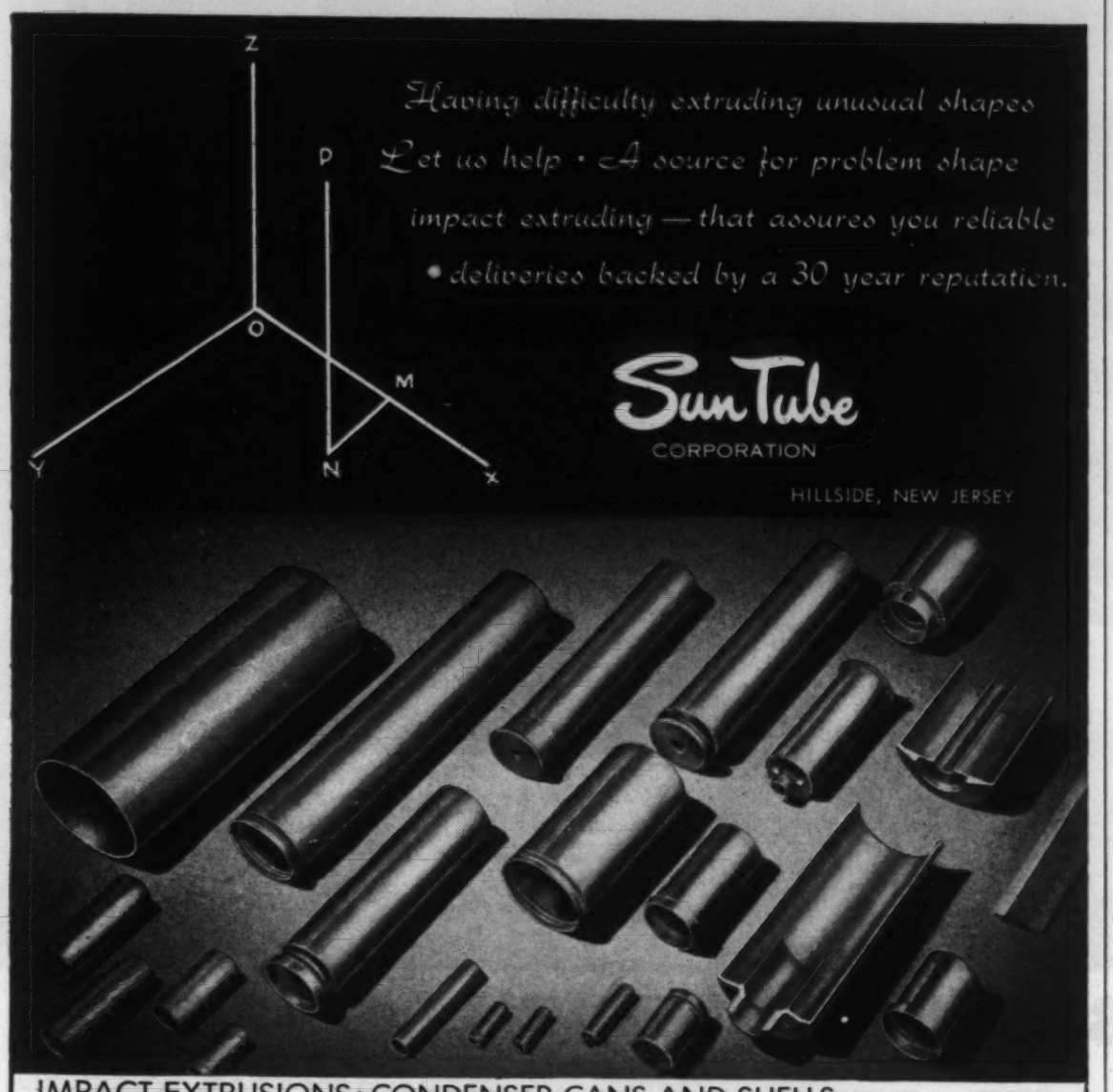

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MATERIALS ENGINEERING NEWS

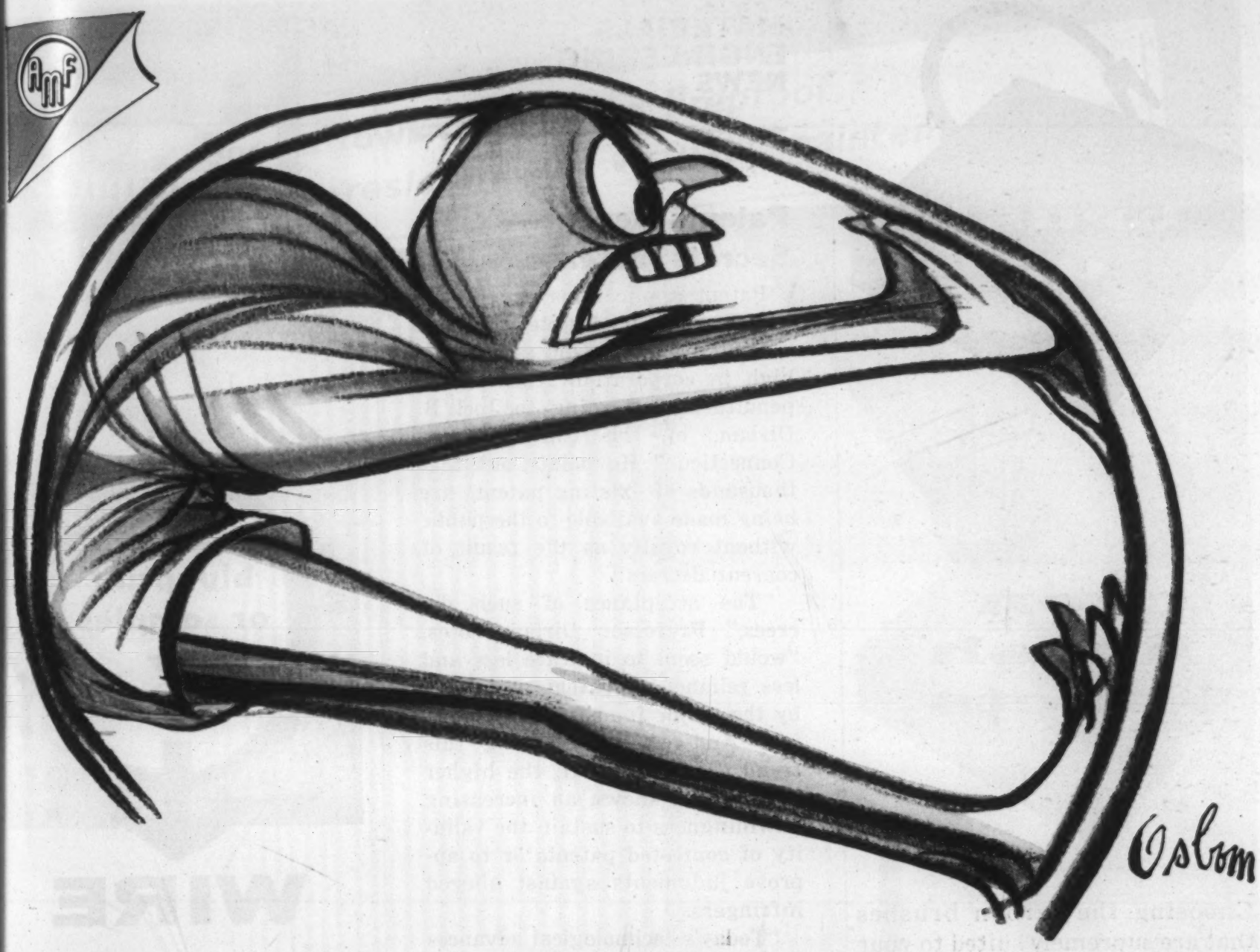
clear that great advantages and applications follow as surely as day and night from the exploration of new basic areas. We believe that we shall make significant contributions to all of the scientific areas represented. In materials we look forward to a future in high temperature refractory materials such as titanium diboride and cerium monosulfide, to new high-purity elemental and compound semiconductor materials, to new forms of carbon and graphite, and to new materials for electronic cooling. In processes we hope to contribute new carbon processing methods, new physical environments in which to carry out chemical reactions, new catalyzation for improving speed and efficiency of chemical reaction, new electrochemical methods for electroplating, and methods for usefully modifying solids or chemicals by using radiation."

Research Information Easily Available

About 20,000 unclassified technical reports on basic research are issued annually by various organizations. Now the Library of Congress and the Office of Technical Services, supported by the National Science Foundation, will undertake wider dissemination of this information. The program, designated Government Research Information, will help any research scientist to: 1) learn what reports in his field are being issued and how he can obtain them, 2) obtain a subscription to a report announcement service, and 3) obtain access to a well catalogued reference collection.

Further information can be obtained from Government Research Information Clearinghouse, National Science Foundation, Washington 25, D.C., att'n: Dwight E. Gray.

(more News on p 252)



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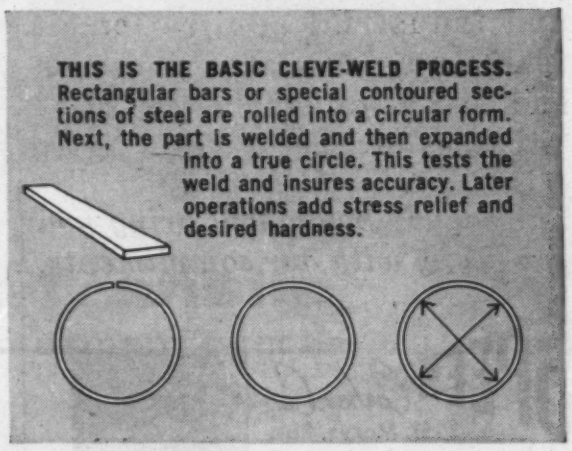
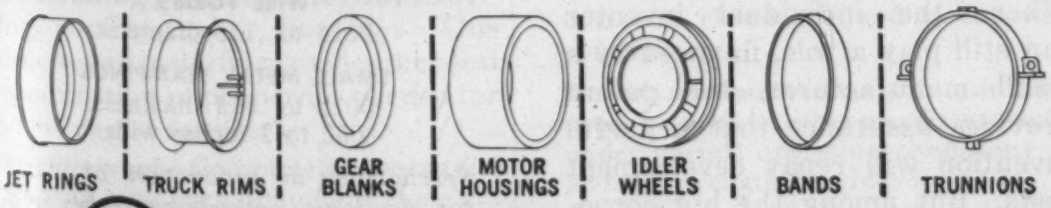
Top Jet-Engine makers specify Cleve-Weld rings

The *design, metallurgy* and *production* of welded circular parts have been Cleve-Weld specialties for 45 years. We've worked with materials from carbon to stainless and the latest aircraft alloy steels. Cleve-Weld has the specialized equipment and experience to do exacting jobs. These are the reasons why America's jet-engine makers procure Cleve-Weld rings. Pratt & Whitney J-57, Wright Aeronautical J-65, General Electric J-47 and other great jet engines testify to our ring accuracy.

Cleve-Weld is also a prime supplier of truck and tractor rims, rings, bands and gear blanks. *Make Cleve-Weld your primary source for all rolled and welded circular parts, too.* We'll show you why in dollars and cents. Write Circular Welded Products Sales Department below.



EXAMPLES OF CLEVE-WELD PROCESS PRODUCTS



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RIMS · RINGS · WELDMENTS

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- ☐ Brochure on Cleve-Weld Process

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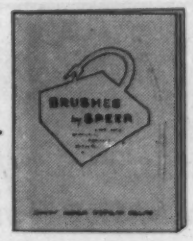

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MATERIALS ENGINEERING NEWS

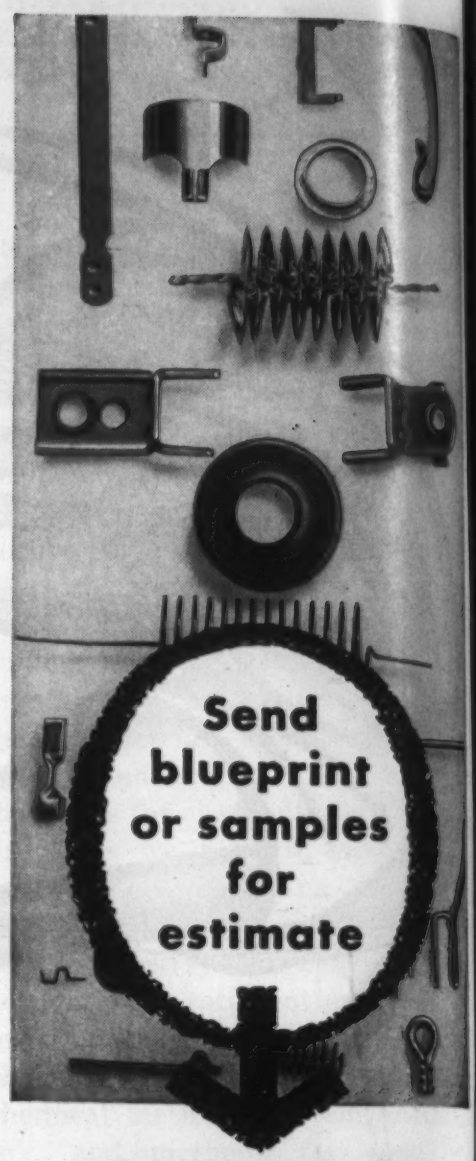
Patents Decline— Secrets Increase

Patent applications are declining in number despite a record rate of inventions and an all-time high in corporation research expenditures, according to Joel B. Dirlam, of the University of Connecticut. He points out that thousands of existing patents are being made available to the public without royalty as the result of consent decrees.

"The acceptance of such decrees," Professor Dirlam notes, "would seem to indicate less and less reliance on patent protection by the major industries of America. And whether causing this trend or reflecting it, the higher courts have shown an increasing unwillingness to sustain the validity of contested patents or to approve judgments against alleged infringers.

"Today's technological advances come almost exclusively from the research laboratories of large companies," Professor Dirlam reports. "In an age when a mass spectrometer costs $50,000, when $40 million must be invested before an artificial fiber is brought to commercial fruition, or when General Motors invests $100 million in a research laboratory, the individual inventor working alone in his laboratory is seriously handicapped in any effort to get the equipment needed for the highly specialized research of modern technology.

"The shift from individual to corporate invention has had a noticeable effect on the commercial value of patent protection. Where the individual inventor can still play a role, financed by a small manufacturer, the patent provides assurance that a useful invention will repay development costs. But among the big corporations, it is rare that a new product or process, once on the market, cannot be somewhat successfully copied by competitors. Thus, a 17-yr patent protection



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We'll prove that our high speed production means lower unit costs for you!

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Perfect straight lengths to 12 feet.
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WIRE FORMS
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SMALL METAL STAMPINGS
.0025 to .035 thickness.
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Specializing in production of parts for electronic, cathode ray tubes and transistors.

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For more information, Circle No. 412

Cooling tower in photograph above constructed by Phillips Cooling Tower Co., Inc., Brooklyn, N.Y.

It's made of J-M Transite®

Corrugated asbestos-cement sheets

Johns-Manville Transite offers many outstanding advantages for constructing cooling tower housings. This time-tested material provides the ideal combination of properties needed for such rugged service.

It's Fireproof—Completely inorganic, Transite can't burn or support flame . . . greatly reduces the ever-threatening hazard of rooftop fires.

It Resists Corrosion—Transite is unaffected by weather, moisture and most corrosive elements found in industrial atmospheres.

It needs no Maintenance—Transite never needs painting or other protective coating under normal operating conditions . . . its high strength provides long life.

It's Attractive—A soft natural grey in color, Transite blends perfectly with modern architecture. In corrugated or flat form, Transite towers make an attractive addition to most buildings.

Write for further information—For further data and names of manufacturers who can supply cooling towers made of J-M Transite, write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

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Johns-Manville TRANSITE THE MODERN MATERIAL FOR COOLING TOWERS

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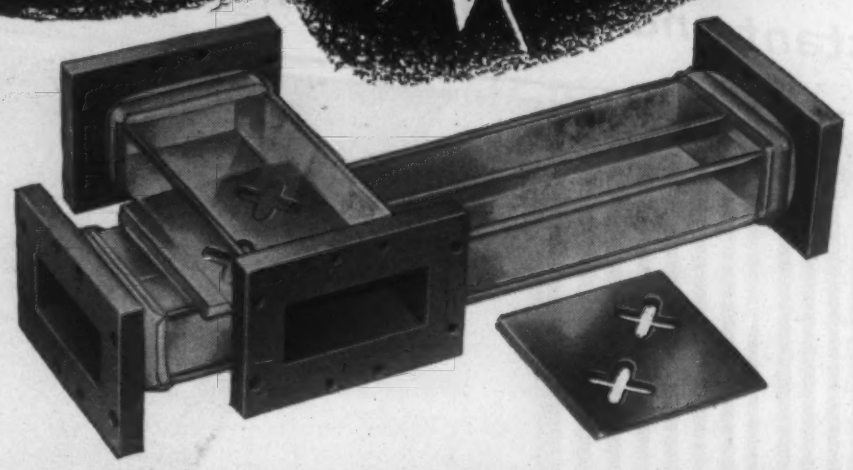
for extreme accuracy and exact duplication



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This unique electroforming process produces precision, internally-shaped parts, such as this microwave coupler, with internal accuracies and configurations unobtainable or economically prohibitive with any other method.

The intricate interior is formed from the inside out, and may include machined parts that are grown in place during electroforming to produce an integral assembly of unusual accuracy, rigidity, and lightness.

Machined flanges are also grown in exact position to eliminate heat distortion associated with fabrication methods.

Offering new concepts in the design of intricate precision parts, Gar-forming provides highest accuracy in any quantities at surprisingly low costs.

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MATERIALS ENGINEERING NEWS

seldom offers the opportunity to recover the heavy research cost and is relatively meaningless commercially. In a highly competitive market, moreover, the advantage of secrecy often outweighs the protection offered by recording a patent."

If it is to function effectively, the patent system must offer an incentive to the large corporation to pursue its researches through teams of scientists, the professor maintains. No longer is it important, he says, or even possible to identify the individual who, as a member of a team, could be called the "inventor" of a new process or product.

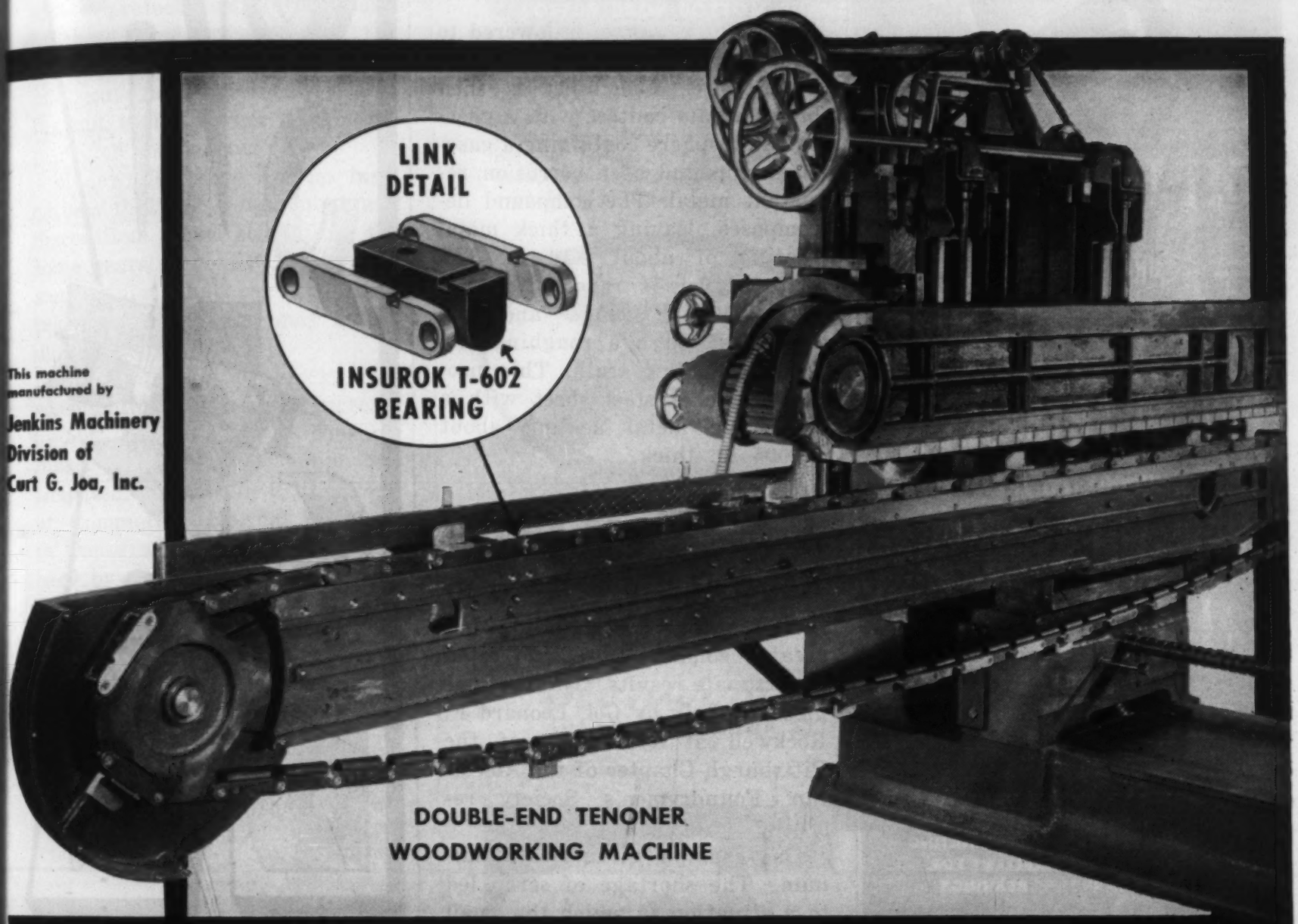
Gas Plating Process Used for Cladding

Two patents on the use of gas plating to clad ferrous and nonferrous metals have been granted to Commonwealth Engineering Co., of Dayton, Ohio. Both patents are refinements and improvements of the continuous casting process for steel and nonferrous alloys.

In Patent No. 2,741,216, the apparatus described uses the hot metal's own heat to effect gas plating. After the metal has issued from a shaping mold and cooled to a solid form, it passes through an insulating sleeve. Here the temperature is reduced to the 300-600 F range where gas plating is possible. The metal is then passed through a plating chamber where the heat from the metal is used to volatilize the plating compounds. These are primarily the metal carbonyls, but also include metal nitrides, hydrides, alkyls and halides. Nickel, iron, chromium, molybdenum, cobalt and mixtures of these can be deposited.

The other patent, No. 2,742,691, describes a method for cladding steel which incidentally overcomes losses due to oxidation and scaling of steel billets. The temperature of the steel billet, cast in the

OIL STAINING ELIMINATED
with Self-Lubricating Plastic Bearings



INSUROK® T-602 replaces metal . . . Doubles life of bearing and track

Lubricating the chain and track on this woodworking machine was formerly a difficult problem. If enough oil were provided for proper lubrication, it would drip and stain the wood. On the other hand, if the oil supply were reduced, the ever-present sawdust, woodchips, and glue particles would cause excessive abrasion and wear—shortening chain life and reducing the accuracy of the machine.

When the manufacturer replaced the aluminum bearing surfaces with inserts of INSUROK T-602—a self-lubricating graphitized phenolic laminate—the problem was solved. Since little or no oil is required, oil leakage and wood staining are eliminated. Furthermore, the life of the chain is doubled, and the accuracy of the machine is maintained.

Investigate the possibilities of this labor-saving, self-lubricating material in your product. Write or phone today for a data sheet on T-602.

Write for newly published bulletin, "Richardson Insurok Laminated Plastics."

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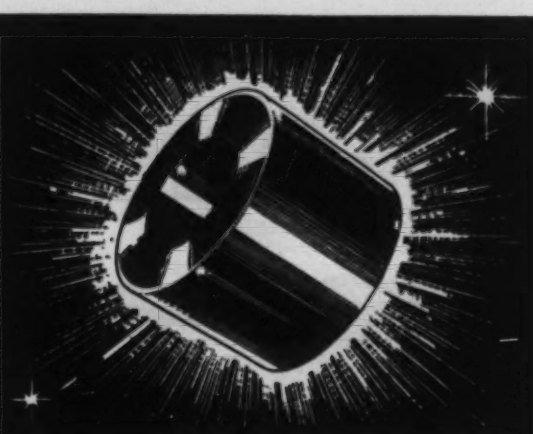

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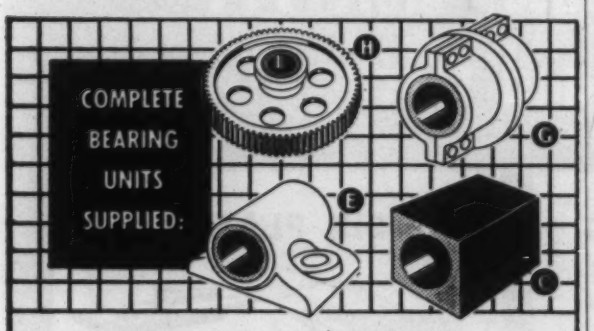

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GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

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MATERIALS ENGINEERING NEWS

1900-2500 F range, is lowered to about 350-450 F in a nonoxidizing atmosphere. The billet is then brought into contact with a gaseous atmosphere containing a gaseous compound of a corrosion resistant metal. The compound decomposes, leaving a thick metal coating of about 0.10 in. The plated billet is reheated to the 1300-2500 F range and hot worked through a roughing and finishing roller train. This produces a clad steel sheet with a protective metal coating about 0.0005 in. thick.

Materials Stockpiling Hits Small Firms

Stockpiling of materials has created some strange, and often unfortunate results. This was the gist of a talk by Col. Leonard F. Rockwell at a meeting of the Pittsburgh Chapter of the American Foundrymen's Society recently.

One example given was aluminum. The shortage of scrap led to a situation in which the small foundries and die casting plants were forced to pay eight cents higher than the primary price for secondary aluminum. After the Government announcement that the stockpile was complete, the secondary price dropped and the small businessman absorbed high inventory losses.

Another case in point was natural rubber. Stockpiling pushed the price to 52¢ a pound and then a 40% drop ensued within three months after the termination of the Government program.

The worst situation of all, Col. Rockwell believes, is in the nickel market. "The nation's estimated needs for nickel will never be met under the 1953 Government agreement to a low fixed price." As a result, defense contractors are encouraged to overestimate their nickel requirements.

In summing up, Rockwell declared that while big business is

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Non-metallic material or parts for manufacturing your product. "KARAK" is manufactured in various combinations of graphite and carbon. To suit your requirements any combination of these materials can be impregnated. Bearings - rings - molds and cores - seals for liquids - air and grease pumps - Diesel engines - air compressors, etc., represent only a partial list of applications. Day by day many needs are developing in industry where this type of material is found to be superior to materials now being used.

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Basic Manufacturers

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able to protect itself through any of these wide price swings, the little businessman has the choice of speculating dangerously or selling out to his bigger and better protected competitor.

Meanwhile, there are no indications that the Government will discontinue nickel stockpiling for some years to come, but there is some belief that the quantities taken for stockpiling may be reduced next year.

On completion of stockpiling, consumption will have to increase by 50% for "industry to consume nickel at the levels of supply anticipated," according to the Dept. of Commerce. Normal increases in consumption have been held back by the need to design away from it and where scarcity of one material encourages interest in other metals, there is always the risk that the consumer will make the substitute his choice for the future. It is possible that these factors could lead to an overproduction of nickel in the long run.

Titanium Sponge by New Producer

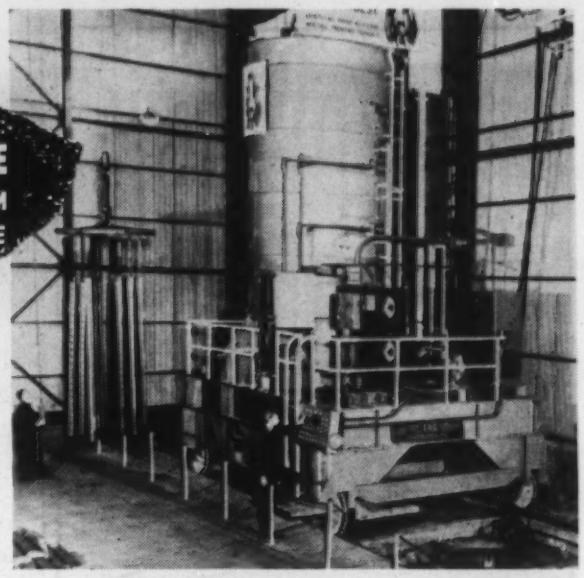
U. S. Industrial Chemicals Co., Div. of National Distillers Products Corp., will put into operation by the end of 1957 a 10 million lb per yr plant for the production of high quality titanium sponge. The plant will be located in Ashtabula, Ohio, near USI's existing sodium and chlorine plant (the products of which will be used in the new plant).

USI will become the first company to enter the titanium field without a government procurement guarantee. Metallic sodium will be used to reduce titanium tetrachloride to sponge. Dr. Robert Hulse, vice president, said the process to be used in the new plant would produce a higher purity sponge at a cost "lower than that of any existing commercial technique."

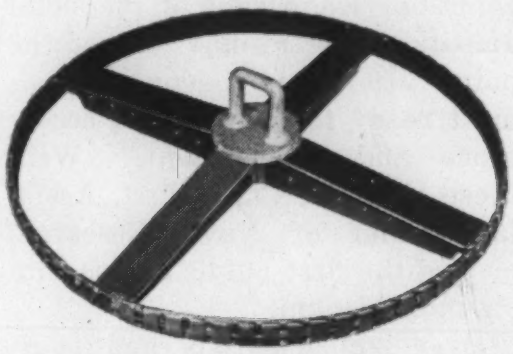
(more News on p 260)

For more information, turn to Reader Service Card, Circle No. 424

6 FT. DIAMETER
STANWOOD FIXTURE
GETS PEAK PERFORMANCE FROM LOFTUS DROP BOTTOM FURNACE



Long steel rails and a variety of other lengthy parts are efficiently handled through heat treating in a large drop-bottom, vertical furnace, and through quenching, at Metallurgical, Inc., Minneapolis, Minnesota.



As with all Stanwood Heat Treating Equipment, correct design and construction and the proper selection of nickel-chromium alloys, assures maximum service, safety, full loading, convenient handling. Send for catalog showing baskets, trays, fixtures, retorts, muffles, carburizing boxes based on nearly a quarter century of experience. Let us put you in touch with the Stanwood Sales Engineer in your territory.

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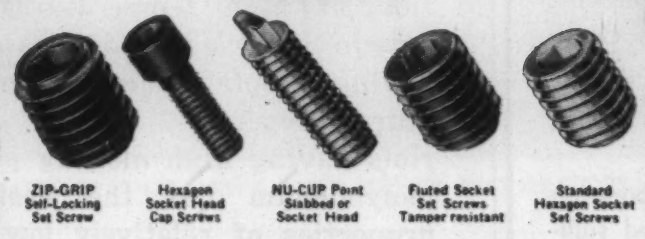

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Now Setko brings to the users of production set screws, the many advantages of Isothermal Heat Treating:

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- Stops Scale
- Minimizes Distortion
- Overcomes Lack of Uniformity
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• In addition to these two outstanding materials, Graphite Specialties Corporation regularly produces components with specially required properties of density, purity, strength, permeability, chemical resistance and machining characteristics.

• Graphite Specialties Corporation components can be produced sufficiently pure for use as a moderator in atomic reactors, to provide exceptionally low erosion rates in rocket nozzles—for use with chlorine at *any* temperature—as crucibles for transistor crystal growth—in difficult metallurgical and chemical applications, as well as for component parts for mechanical equipment.

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• Write today for information relating to your specific component requirements to Graphite Specialties Corporation, 64th Street at Pine Avenue, Niagara Falls, New York.

For more information, Circle No. 431

MATERIALS ENGINEERING NEWS

Symposium Finds Molybdenum 'Ready'

"The technology of molybdenum has reached the end of a distinct phase in its development. Research has completed its initial function. Knowledge of the metal and its properties has reached the point where molybdenum is almost ready for commercial acceptance and development." With these remarks, Capt. Hart, Assistant Chief of Naval Research, opened the first public symposium on molybdenum.

Over 300 scientists and engineers concerned with the development of structural materials for high temperature attended the symposium sponsored by the Office of Naval Research to discuss the developments in molybdenum obtained during the past seven years through cooperative research.

Interest in molybdenum developed when it became apparent about ten years ago that ability to design heat engines for operation at high temperatures had outrun knowledge of materials having acceptable elevated temperature properties. Among materials having high melting points, molybdenum has the desirable properties of relatively low density and excellent high temperature strength. Its major disadvantage, poor oxidation resistance at high temperatures, is still the stumbling block in applying the metal.

Although molybdenum is still far from ready for large scale application in air at high temperatures, significant advances have been made during the past few years. Ingot weight has increased 50-fold and section size of wrought products has increased 25-fold. Fabrication and forming of complex shapes has been achieved together with substantial improvements in uniformity and ductility of wrought products. Alloys having 100-hr stress rupture properties of 50,000 psi at

Earth Satellite's Magnesium Shell—

International News Photos

—typical of B & P's Skill in Fabrication

To a skin of non-uniform thickness of 0.015" to 0.030", interior bracing must be welded or secured with screws. Weight-savings of fractions of ounces can be highly important. The outside, manufactured to a tolerance of four micro-inches, must be polished to an intense mirror brightness.

Magnesium was chosen for the structural material. B&P was chosen to work out the complexities of the fabricating and finishing operations and build the spheres . . . Whenever you are faced with a difficult or delicate operation-problem in Magnesium or Titanium, a talk with B&P engineers is well worth while.

Engineering Facilities in Detroit and Los Angeles

. . . Write for Titanium and Magnesium engineering data—also folder on B&P's facilities to handle tough jobs.

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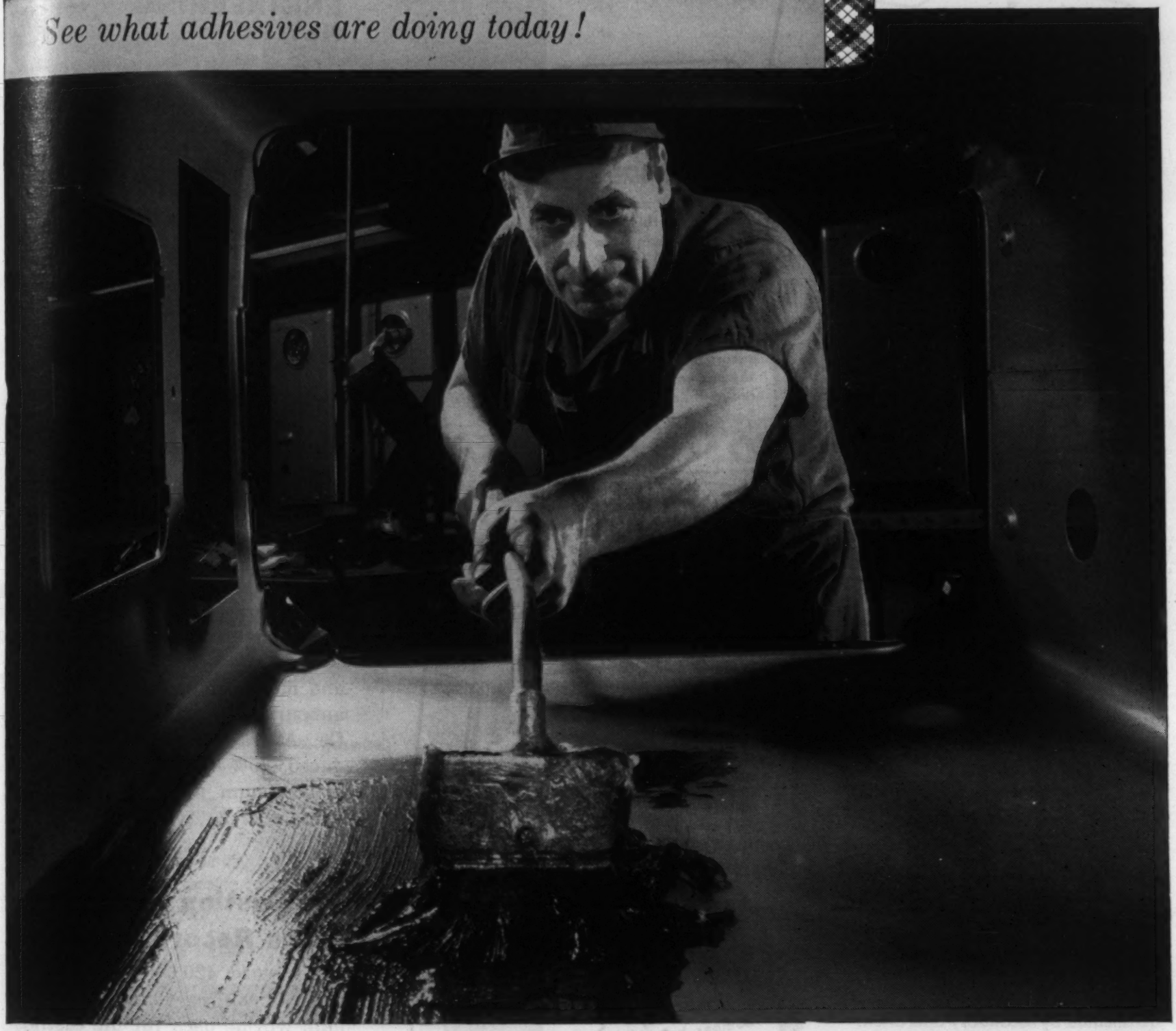

OUT OF THIS WORKER'S BRUSH FLOWS A MODERN FASTENER THAT HELPS BUILD BETTER INCINERATORS. IT'S A RUGGED 3M ADHESIVE.

Setting a tougher trap for heat

It's got to be hot—up to 350°F.—inside this incinerator outer cabinet, so that even *wet* refuse will burn.

To hold the temperature, heat must be kept steadily on the job. A 3M adhesive, EC-321, does it by fastening fibrous glass insulation for keeps inside the cabinet. Trapped, the heat stays hard at work, does the job.

But EC-321 does more than just guard incinerator efficiency. It helps build them more durably, more economically, too. It eliminates the hot spots, weld marks and half the labor of former methods.

Since switching to 3M Brand adhesive, the product engineer hasn't had one complaint of adhesive failure.

Hundreds of other 3M adhesives serve industry in a thousand varied uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

To boost product quality and cut costs, consult 3M research. Contact your 3M Field Engineer. For a free booklet and more information, write: 3M, Dept. 611, 417 Piquette Ave., Detroit 2, Michigan.

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CASE HISTORY 1

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

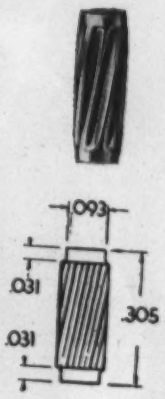
CASE HISTORY 36

REQUIRED:

Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:

Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.



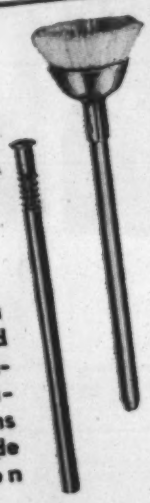
CASE HISTORY 89

REQUIRED:

Customer looking for low cost, high production rate method of producing mandrels for rotary dental brushes.

HASSALL SOLUTION:

Hassall-originated design for cold-heading replaced chamfered end with tumbled, round end; maintained rigid specifications for straightness and made low-cost production possible.



CASE HISTORY 37

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier — can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 21/.. Westbury, Long Island, New York.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

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MATERIALS ENGINEERING NEWS

2000 F are available commercially. Coatings have been obtained that afford protection at 1800 F for 1000 hr and 2000 F for 500 hr under simple conditions, a promising development in the solution of the high temperature oxidation problem.

Molybdenum Use Up—Prices Increased

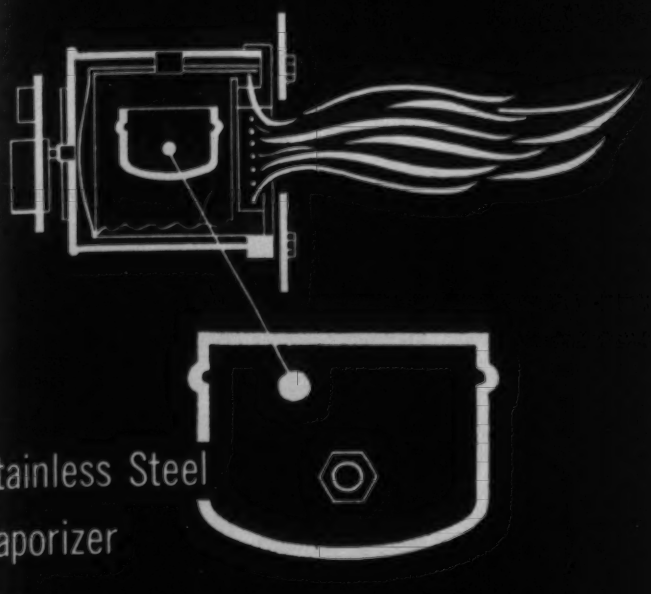
Consumption of molybdenum increased 15% during the first six months of 1956 over the same period last year and was the highest since 1943, according to the Bureau of Mines.

Simultaneously, changes in base prices of metallic molybdenum and molybdenum-base alloys were announced by Climax Molybdenum Co. Average alloy prices were reduced 30% while pure metallic molybdenum prices increased an average of 20%.

Die Casting Institute Plans Record 1957

A record 420,000 tons of zinc and 372 million pounds of aluminum will be used for die castings in 1957. This was the forecast made at the die casters' 29th annual meeting held in September in Chicago. In the face of a drop for 1956 indicated by consumption to date, the Institute predicts 1957 consumption will top the 1955 record by 10,000 tons of zinc and 20 million lb of aluminum. Figuring prominently in the survey is the assumed production of 6.5 million automobiles with an increased use of castings per car.

The Institute pointed with pride at the rate of growth achieved in the cooperative pooling of the know-how of competitive producers, announcing the addition of ten new companies to the membership. Companies enrolled now total 111 and produce 80% of all die castings slated for



Stainless Steel
Vaporizer
Cup

Stainless Steel replaces cast iron in burner cup... **saves 60¢ a part, cuts weight 90%**

Big cost savings . . .

OLD CUP
(Cast Iron—1.2 to 1.4% chromium)

Cost of casting	$1.090
Machining grinding, boring, drilling, tapping	0.274
Total	$1.364

(Material and Labor)

NEW CUP AND SPUD
(Type 304 Stainless Steel)

Cup material	$0.330
Spud material	0.100
Drawing	0.119
Welding	0.200
Punching, beading cup and Machining spud	0.132
Total	$0.881

(Material and Labor)

Material and Labor Saving	$0.483 (35%)
Overhead Saving	0.122
Total Saving, per cup	$0.605

About a year ago a manufacturer of oil burners changed specifications from cast iron to stainless steel for this vaporizer cup.

It saves him $0.605 on each part—35 per cent on materials and labor alone—and practically eliminates service failures.

By welding a stainless steel spud (machined from ¾" hexagon-shaped bar) to the cup (drawn from .028 Type 304 stainless strip) the burner producer gets a more dependable part at much less cost.

The vaporizers formerly used not only created service problems but took a high toll in tool grinding and replacement costs. Switching to stainless ended this headache too.

Weight cut 90%

Weight went down with costs. The cast iron cup weighed 5 pounds; the stainless cup weighs only ½-pound. What's more, the stainless cups are virtually immune to "burn-out."

It's Armco for Stainless

Armco's wide variety of stainless steels makes it possible for you to select the one right grade for your products. We produce all standard and many special grades in sheets, strip, plates, bars and wire. Get more information about Armco Stainless Steels by calling the Armco Sales Office near you, or writing us at the address below.

Armco Steel Corporation

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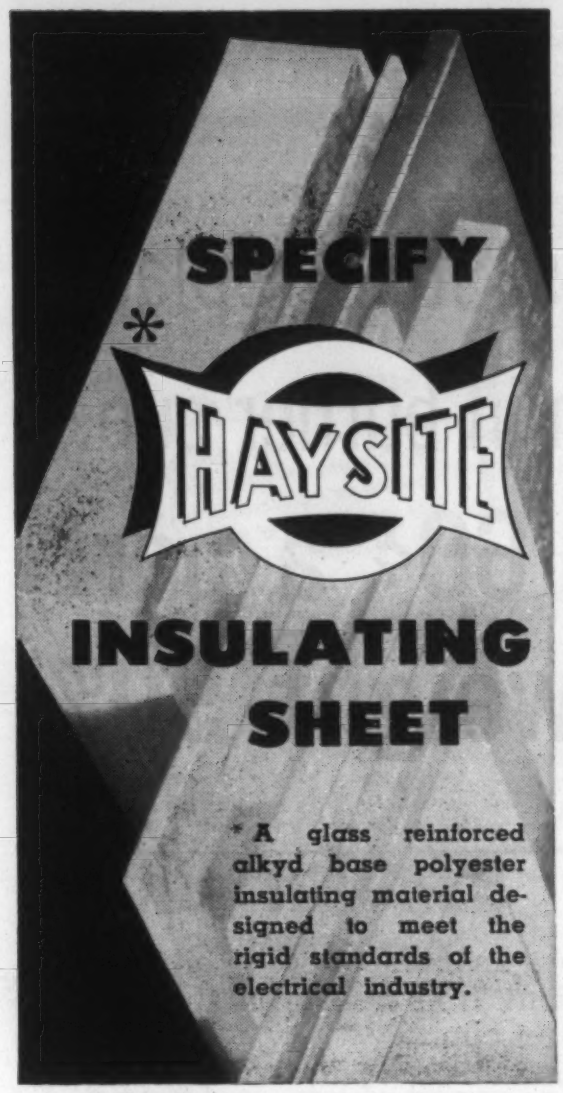

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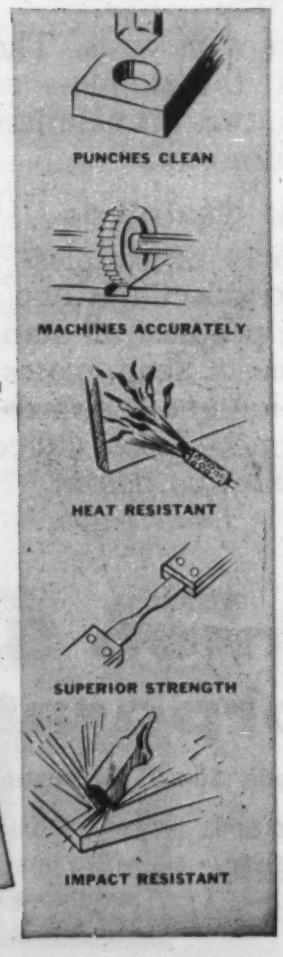

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MATERIALS ENGINEERING NEWS

sale in this country.

Research projects

Important projects of the Institute's Research Foundation will continue to be advanced. Principal objective is to develop methods of economically die-casting high-melting-point metals, such as copper-base alloys and ultimately the ferrous metals. Research progress reports now indicate that the development of improved die materials will soon result in economical small-part production of brass die castings.

Other ways in which the Institute is planning ahead include expansion of the Certified Zinc Alloy Plan. Discussions in Chicago indicated that benefits are being gained by both producers and consumers. The CZAT licensing certificate requires the voluntary submission of production run die castings to an unbiased recognized independent laboratory.

New officers

Institute business included the reelection of William J. During as president, election of C. J. Sheehan as vice president, and reelection of David Laine and W. J. Parker as secretary and treasurer, respectively.

The annual Doehler Award for outstanding contributions to the die casting industry was presented to Austin T. Lillegren, vice president of Madison-Kipp Corp.

What's Happening in Prices and Supply

Prior to August the total production of primary aluminum was running 13% higher than last year. In fact July saw an all-time monthly peak output of 151,624 tons. Then came the strike which began Aug 1 and tied up four Alcoa plants for two weeks and four Reynolds plants for the entire month. August production dropped 60,000 tons to a 3½-yr low and recovery continued slowly through September. Despite these losses the industry foresees a total

33 1/3% parts reduction

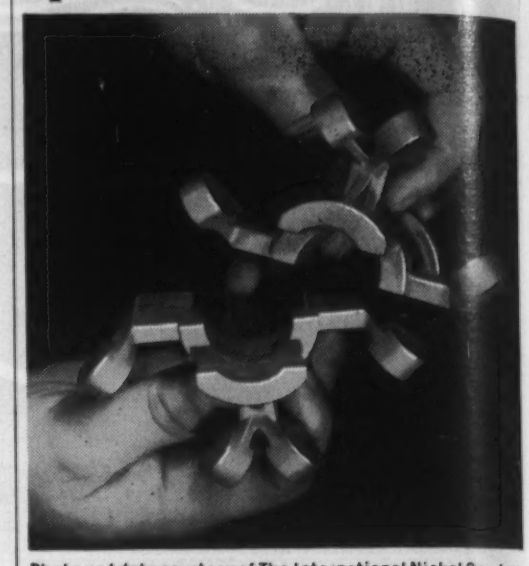


Photo and data courtesy of The International Nickel Co., Inc.

with INVESTMENT CASTING

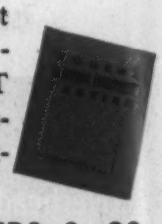
This intricate collar was formerly made in six parts; now it's produced in two by Investment casting. It is required in underwater "ears" for sub hunting by Navy helicopters.

The former operation required a large amount of fabrication and handling that proved far too costly. The solution was Investment casting. This modern technique greatly simplified production by eliminating all blanking, forming, pre-machining and welding. Final assembly was far easier and overall costs were greatly reduced.

Put these real savings to work on your small parts production.

WRITE TODAY for the INVESTMENT CASTING STORY

This free 12-page booklet —"MODERN PRECISION INVESTMENT CASTING"—contains detailed data on the Investment casting process.



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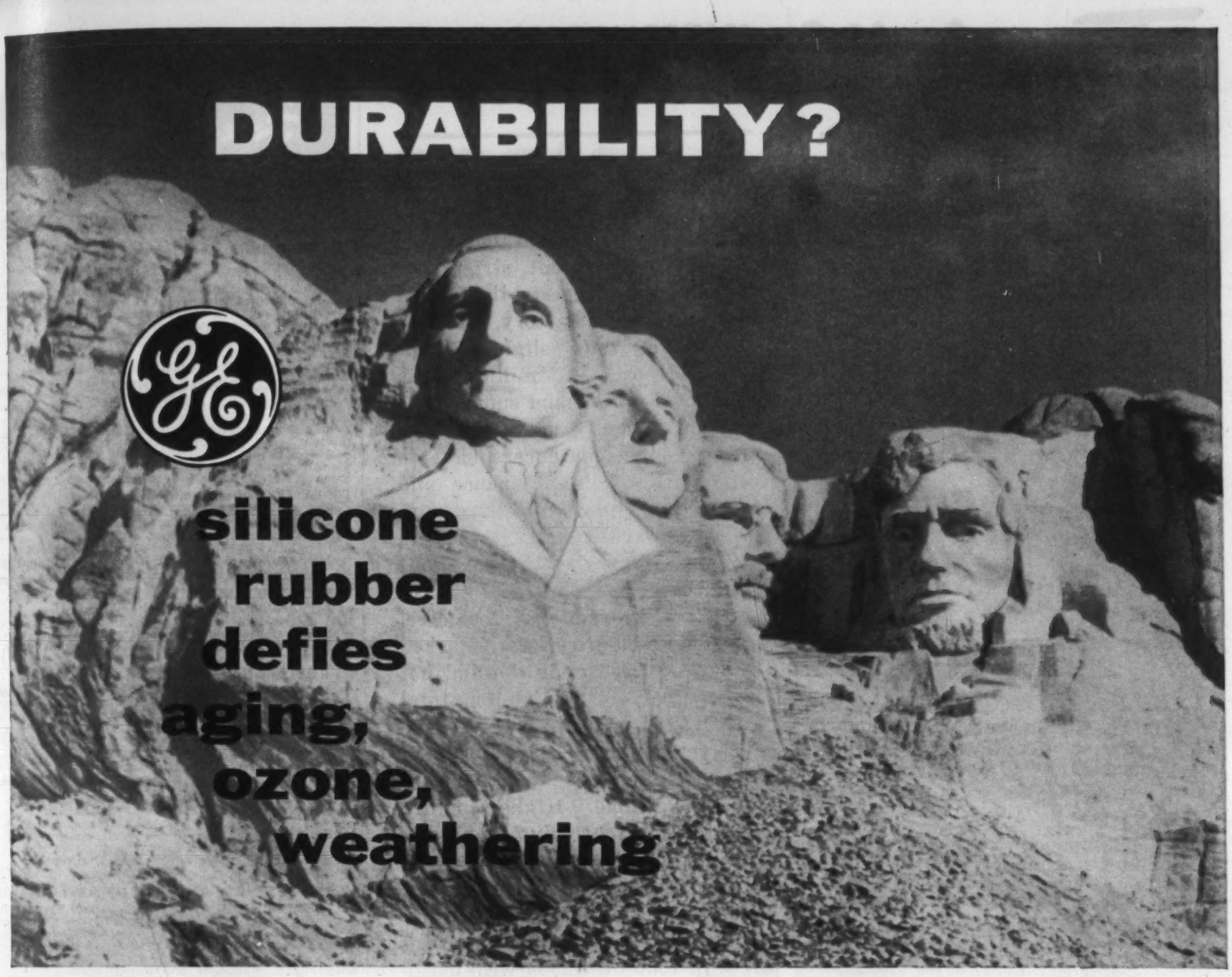


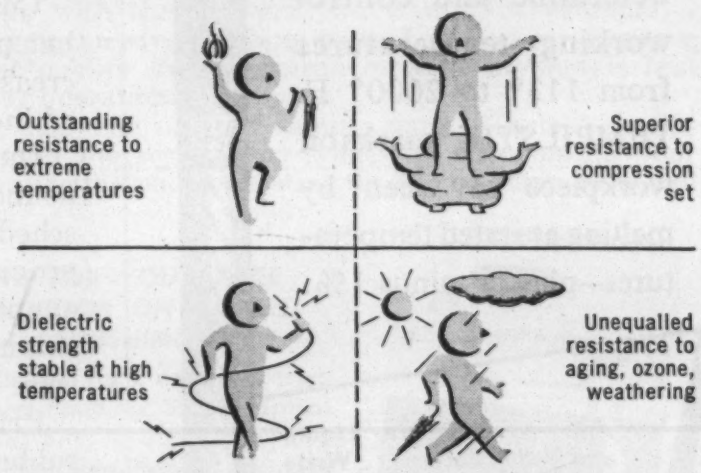
Looking for rubber with *unusual durability*? General Electric silicone rubber offers exceptional resistance to aging, ozone and weathering. For example, it provides *virtually ageless* insulation for transformers and turbine generators. It makes aircraft seals which are *unaffected by weather or by ozone concentrations* at high altitudes. If *durability* is what you need in rubber parts, specify General Electric silicone rubber!

Where can YOU use G-E silicone rubber?

There's a kind for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 300 offers the best recovery after compression *of any known rubber!* Class 700 provides serviceability at temperatures *up to 600 F!* Which class is best for *you?*

For more details on G-E silicone rubber, see your "Sweet's Product Design File."

G-E silicone rubber provides...



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MATERIALS ENGINEERING NEWS

output for the year well in excess of last year's 1,565,000 tons.

Despite its recent strike, the steel industry expects the second best output in history, perhaps 114 million tons—slightly below 1955's record 117 million tons. With over-all demand sufficient to warrant capacity operations, the only problems producers have to cope with are maintenance and production. Some mills are running below rated capacity, others above it, but they average out near the 100% mark.

Rising shipments of tool steel in the first half year were marked by large increases in die and hot work products. Although total tool steel shipments increased 23% over last year's, increases among the various classes were highly variable. Highest figure was for high chromium die steels —a rise of 42%.

Figures only recently released show that domestic consumption of primary magnesium increased 17% in 1955 over 1954 with usage for sheet and plate showing the greatest change. Production, however, decreased 10%.

Consumption of copper is rising but production of the metal is increasing and continues in excess of industry requirements.

During September DuPont announced revision of the price schedule for Teflon resins, setting progressively lower prices for quantity orders. Full truckload shipments of any one composition were reduced 40¢ per lb.

Price of molded and extruded rubber products made by the U.S. Rubber Co. was upped 2½ to 5¼%. The increase was attributed to wage rises and hikes in raw material costs.

Protecting Molybdenum

Coming in December

An authoritative, detailed summary of the present status of protective coatings for molybdenum.

☐ **CHROMIUM** *2 Volumes edited by M. J. Udy.* Written by 30 top experts, these volumes offer latest accurate data on the sources, properties, manufacture and use of metallic chromium, chromium alloys and chromium chemicals. Vol. 1 covers the chemistry of chromium and its compounds. Vol. 2 describes the metallurgy of chromium and its alloys. ACS Monograph.
☐ Vol. 1: 1956, $11.00
☐ Vol. 2: 1956, $11.00
☐ COMBINATION PRICE: Both volumes for $19.50

☐ **THE CONDENSED CHEMICAL DICTIONARY,** *New 5th Edition edited by Arthur and Elizabeth Rose.* Over 30,000 revised, up-to-date entries; 1,220 double-column pages as compared with 760 pages in the previous edition; more than 6 years in preparation; enormously expanded trade name information obtained directly from producers; thumb-indexed for quick reference; larger, easier-to-read print. 1956, $12.50

☐ **LATEX: Natural and Synthetic** *by P. G. Cook.* Covers the origin and use of natural latex; the technology of natural rubber latex, including concentration, vulcanization and processing; synthetic latex; and such end-products as foam rubber, rubberized fibers, adhesives, display models and flooring. 1956, $3.50

☐ **BIOLOGICAL TREATMENT OF SEWAGE AND INDUSTRIAL WASTES,** *Volume 1, edited by McCabe and Eckenfelder.* Covering aerobic oxidation, this volume describes the principles of bio-oxidation, the theory of oxygen transfer, and the design and operation of typical sewage and industrial waste treatment processes. 1956, $10.00

☐ **RESISTANCE WELDING: Theory and Use** *by the Resistance Welding Committee, American Welding Society.* Compiled by leading experts in the field. Covers principles, definitions of terms, processes, machines, controls, electrodes, jigs and fixtures, welding symbols, weldability of metals, precautions required, weld quality, specifications, control, and the welding of aluminum. 1956, $4.50

☐ **SODIUM, Its Manufacture, Properties and Use** *by Marshall Sittig.* Combines latest developments in the manufacture, handling and use of sodium with a critical coverage of its physical, chemical and thermodynamic properties. Amply supplied with flow sheets, equipment illustrations and photos of actual sodium handling operations. Contains over 2,000 references to published literature. ACS Monograph, 1956, $12.50

☐ **POLYESTERS AND THEIR APPLICATIONS** *by Bjorksten, Tovey, Harker and Henning.* The first comprehensive survey of the polyester field from raw materials to fabricated products. Text plus over 3,300 references cover almost every phase of the production and use of polyesters including saturated polyesters used in the production of fibers, films, elastomers and foamed plastics. 1956, $10.00

☐ **HANDBOOK OF BARREL FINISHING** *by Ralph F. Enyedy.* Covers every phase of barrel finishing from cleaning and deslugging to coloring, polishing and burnishing in step-by-step sequence. More than 150 complete specification sheets provide all the information necessary for finishing a large variety of parts. 1955, $7.50

☐ **BRAZING MANUAL** *by the Committee on Brazing and Soldering, American Welding Society.* Describes the principles, equipment and procedures involved in the 9 major brazing processes; each operation from surface preparation to postbraze inspection; and techniques of brazing aluminum, magnesium, copper, steels, nickel and many other metals. 1955, $4.75

☐ **ELECTROPLATING ENGINEERING HANDBOOK** *edited by A. K. Graham.* Brings you newest information on processing techniques and the engineering factors involved in constructing and installing plating equipment. Covers the design of parts to be plated, specifications, processing sequences, testing, maintenance, waste treatment, and much, much more. 1955, $10.00

☐ **TITANIUM AND TITANIUM ALLOYS** *by J. L. Everhart.* Summarizes and coordinates the extensive periodical literature which has appeared since titanium became of commercial significance. Emphasizes the properties, fabrication, machining and applications of commercial titanium and those alloys now in production. 1954, $2.95

☐ **ADHESIVE BONDING OF METALS** *by George Epstein.* Shows how to determine if an adhesive-bonded joint would be advantageous, what type of adhesive to select, how to employ it, and how to design the joint for best performance. Covers the chemistry, formulation, and factors affecting the strength of adhesive bonds. 1954, $2.95

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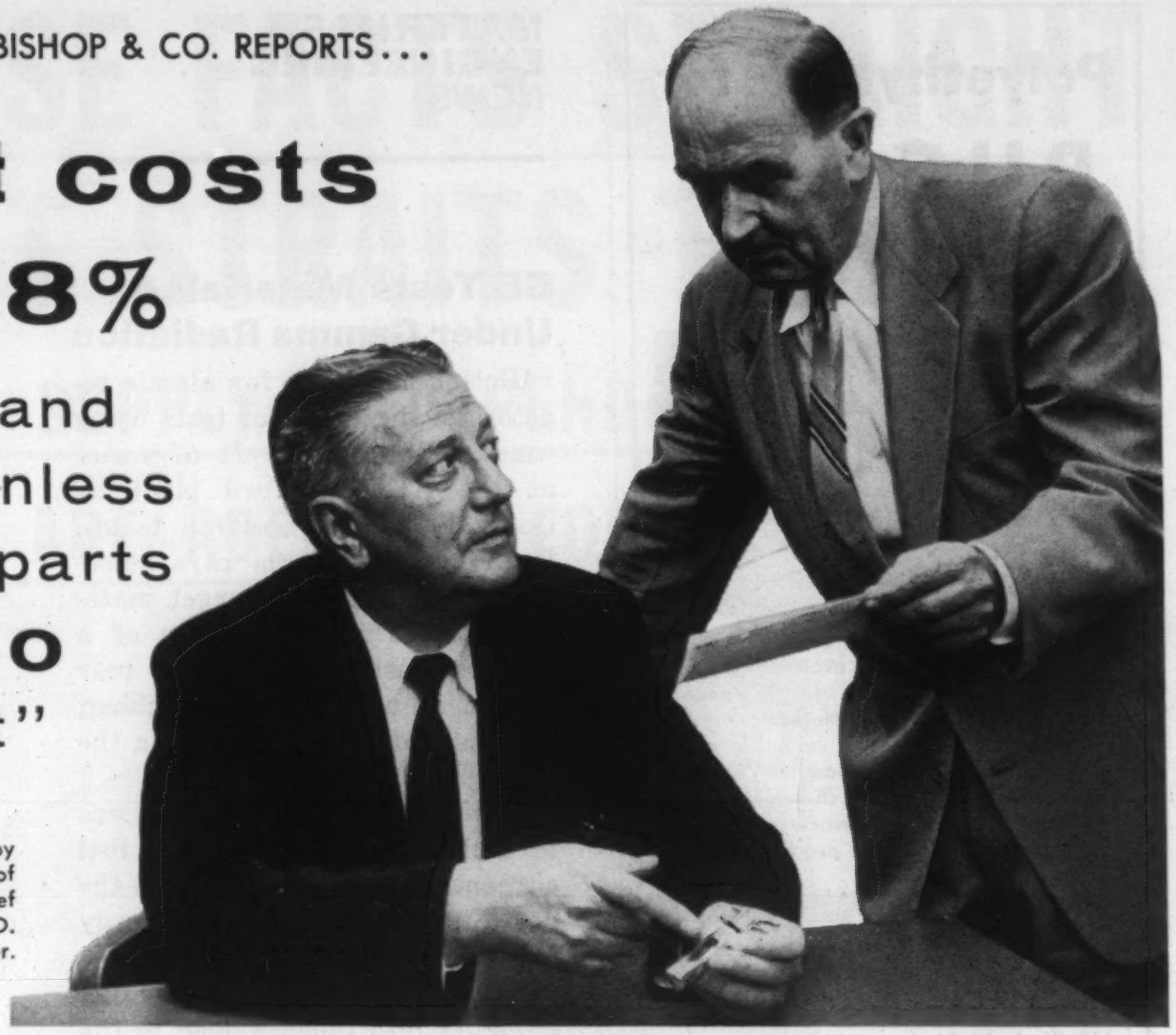
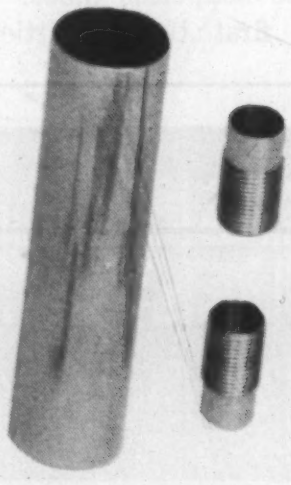
THE CHIEF ENGINEER OF J. BISHOP & CO. REPORTS...

"We cut costs 98.8% by deburring and polishing stainless steel tubular parts with ALMCO equipment"



SAVINGS OF $6,917.50 PER YEAR by controlled barrel finishing is the topic of discussion between J. H. Gettig, Chief Engineer of J. Bishop and Co., and O. D. Ladley, Almco Eastern Branch Manager.



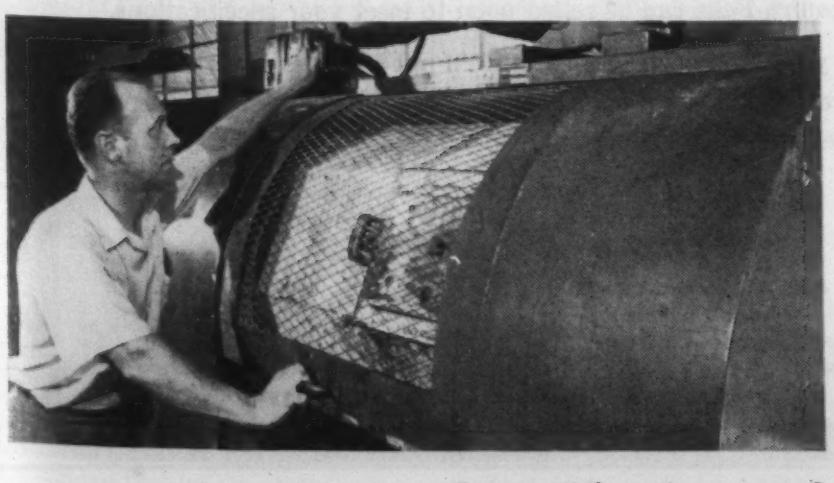
HALF A MILLION delicate parts for recording instruments and fountain pens are deburred and polished each year at J. Bishop & Company of Malvern, Pennsylvania. Each must meet rigid requirements in uniformity of size, smoothness and high polish.

A costly process? Yes, when you consider the way Bishop used to finish them by machine reaming, hand scrapers, wire brushes and belt polishers.

Today this plant uses an Almco Model DB-200 finishing barrel, which gives three important advantages: (1) High volume, low cost deburring and finishing, (2) precise control during finishing process, (3) product improvement.

Here's how controlled barrel finishing worked out for J. Bishop & Company. They cut finishing costs by 98.8% ... practically eliminated rejects ... raised average output from 200 parts to 6000 parts per hour. Cost per unit for finishing has been cut from .014¢ to .00016¢. Annual savings total $6,917.50.

Chief Engineer J. H. Gettig sums it up this way, *"Our decrease in costs and our product improvement leaves no basis for comparison."*



PART OF A HALF MILLION ANNUAL OUTPUT, this batch of delicate instrument parts is being run in an Almco DB-200 barrel finishing machine.

Almco equipment is also used throughout the world for descaling, grinding, work-hardening, rust-inhibiting and other deburring and finishing operations. Equipment is available for small and large parts, high or low volume work. Each is designed to handle ultra-low microinch surfaces and close tolerance radii.

LEARN HOW MODERN BARREL FINISHING CAN IMPROVE YOUR PRODUCT

Almco's new, technician-staffed lab in Albert Lea, Minnesota can help you with your product parts. We will examine your product parts, run them through tests, and come up with the answers you want. For example — where you can save finishing costs, how you can improve product quality and appearance, what method is best for your operation.

Why not send us your sample parts? Enclose specifications on the results you want. Or write us on your company letterhead requesting an Almco engineer to call on you.

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52 pages of facts and processes on barrel finishing. Shows typical installations, how to select the proper finishing barrel. Includes detailed cost chart on finishing of typical parts. Send for your free copy today.

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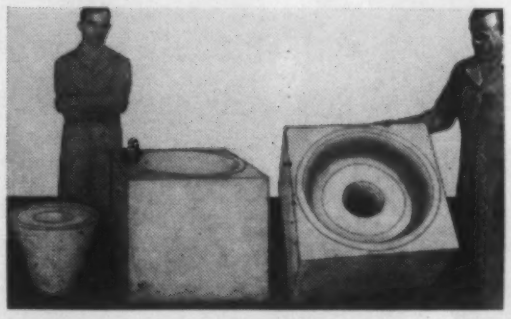
Polyethylene for

RUGGED SERVICE



Duke University, after evaluating other materials, ordered these large castings made of WESTLAKE high-molecular-weight virgin Polyethylene. This versatile material, available in every possible form, is inexpensive, light weight, chemically inert, fungii resistant, easy to machine and has high frequency di-electric properties.

Westlake plastics co.

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MATERIALS ENGINEERING NEWS

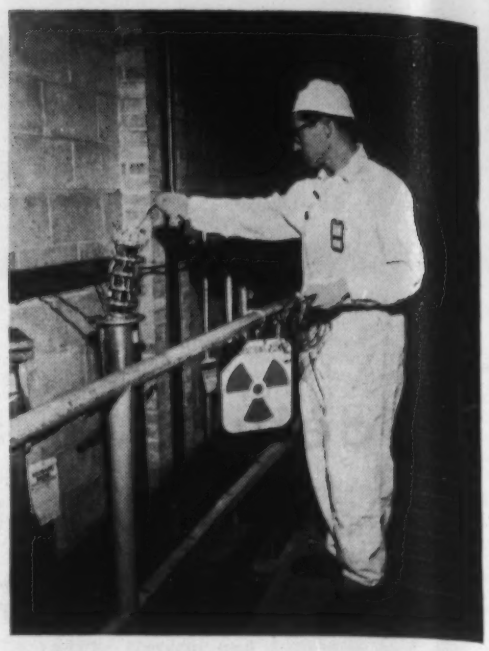
GE Tests Materials Under Gamma Radiation

Better materials for atomic reactors is the object of tests being conducted under 20 ft of water at the AEC Hanford plant by General Electric research teams. High energy gamma rays noiselessly bombard test target materials placed at the bottom of a storage basin pool at the rear face of a nuclear reactor. Rubber, plastics and metals are among the materials being tested.

Initial purpose of the basin was to cool intensely radioactive fuel elements after discharge from the reactors. Now this waste energy is being utilized.

Operators remotely load the fuel elements into tubes welded to the sides of a cylindrical unit devised to direct the gamma rays. Samples to be bombarded are lowered into the cylinder until they line up with the uranium slugs. Some of the test samples have been exposed for more than a year.

Many rubber samples are reduced to shapeless blobs. Polyethylene first turns brittle, then



***Rubber strips** in metal basket are lowered through metal tube to bottom of 20-ft basin of water where they will be exposed to intense gamma radiation from uranium slugs.*

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Dept. 24L, 1028 Connecticut Ave.
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Space prevents us from listing all the reasons why we believe engineers can improve their career at Lockheed. There are many. But if our remarks have made sense to you, write and we can explore your opportunities at Lockheed through personal interview or phone. Resumé form at right is simply for your convenience in contacting us.

Mr. E. W. Des Lauriers, NA-39-11
Lockheed Aircraft Corporation
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MATERIALS ENGINEERING NEWS

rubbery, and finally cracks. Many types of glass take on a smoky brown hue. As a result of these tests some materials previously used in atomic reactors have already been replaced by others more resistant to radiation. In addition, the studies are aiding in the development of new materials through rearrangement of molecules in existing materials.

Malleable Research by Five-Part Effort

Five leading malleable casting foundries have incorporated an organization which will be concerned with the technical and not the marketing phases of industry.

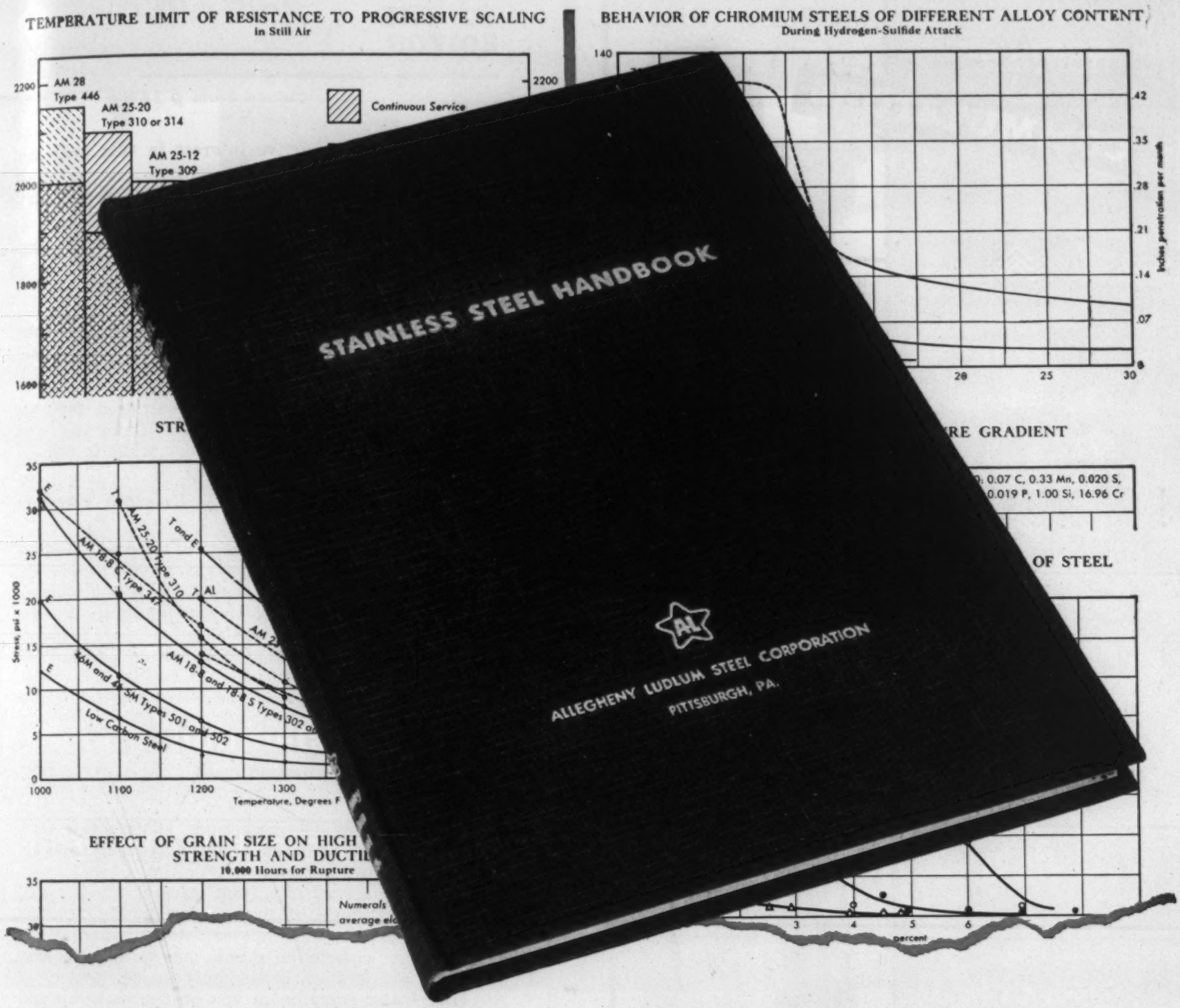
Known as the Malleable Research and Development Foundation, it will seek ways of making better castings at lower cost. It will cooperate with all other branches of the foundry industry. Main objectives will be to promote the general welfare of the malleable castings industry through research and to assist in the discovery and development of new products, better processes and improved equipment for production foundries. The Foundation will use the laboratories of commerical organizations, engineering schools, member companies and equipment manufacturers.

Organizers of the Foundation are: Albion Malleable Iron Co., Auto Specialties Mfg. Co., Dayton Malleable Iron Co., National Malleable & Steel Castings Co. and Wagner Malleable Iron Co.

Nickel Silvers
Coming in December

Because of their white color and excellent corrosion resistance nickel silvers are specified for a variety of functional and decorative parts. A 16-page manual describes the properties, fabricating considerations and applications of this important group of copper alloys.

For more information, turn to Reader Service Card, Circle No. 586



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Your copy of the Stainless Steel Handbook will be sent—*without charge*—upon request. Our only stipulation: please make your request upon your company letterhead. • Write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

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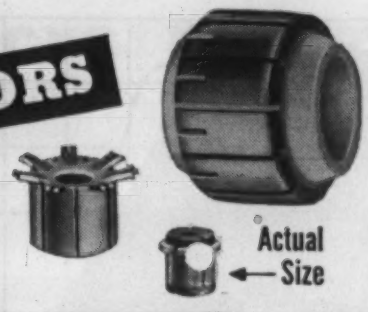

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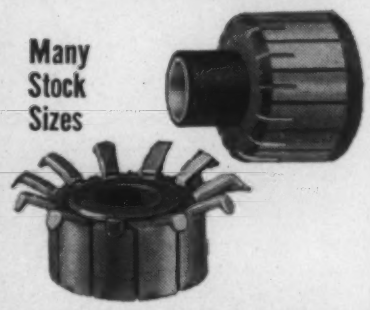

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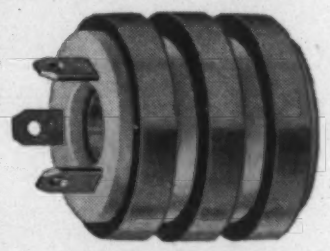

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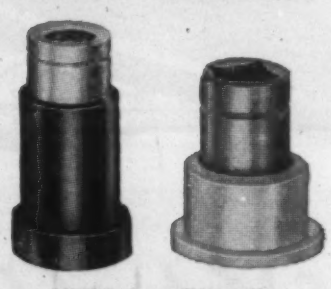

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LETTERS TO THE EDITOR

continued from p 14

try taking a more active interest in this neglected problem.

HAROLD BUHL, Assistant Professor
Iowa State College of
Agriculture and Mechanic Arts
Ames, Iowa

To the Editor:

Will you please send me a bibliography and brief outline of the best known techniques in thinking procedure as mentioned on p 302 of your Sept '56 issue of MATERIALS & METHODS.

I certainly feel there is a real need for this type of study in the seminars in the junior year and a one hour course in the senior year while in college.

A. D. H.
Research Engineer

The three letters above are typical of many we have received which comment on our September editorial. Response to our offer in the "Last Word" column (same issue) to supply bibliographies on the subject of thinking techniques was also gratifying. Requests are being answered individually and in addition we are considering the publication of articles which will relate these techniques to the solving of materials selection problems.

Magnets and a bouquet

To the Editor:

In your Aug '56 issue under "Materials Outlook" mention is made of a new permanent magnet material in powder form.

We are engaged in a small project which might contemplate the use of such material. May we ask for particulars in reference to the organization engaged in this research or production as the case may be? Your cooperation is sincerely appreciated.

May I also compliment you on the make-up and selection of articles for your publication. It has been most informative and helpful to members of our group in the past.

HOWARD THURSTON
Republic Aviation Corp.
Farmingdale, L. I., N. Y.

For information on the new magnet material write Westinghouse Research Laboratories, Box 2278, Pittsburgh 30, Pa.

Name trouble

To the Editor:

The improved gasketing material described on p 149 of your September issue is now being marketed under the name Vistex with "Teflon." (Vistex is an American Felt Co. registered trademark; Teflon is a DuPont registered trademark.)

During the development and evaluation of this material the name Teflon Vistex was used internally in describing the product. However, you can well appreciate the fact that we would not wish to use DuPont's registered tradename for their tetrafluoroethylene resin as a modifying adjective for one of our products.

THOMAS J. GILLICK, JR.
Director of Engineering
American Felt Co.
Glenville, Conn.